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# The Graduate Bulletin

## MABLY, A TRUE PROPHET OF REVOLUTION

BY CHARLES KUHLMANN, FELLOW IN EUROPEAN HISTORY

De Tocqueville opens his *Ancien régime et la révolution* with the statement that "There is nothing better fitted for recalling philosophers and statesmen to modesty than the history of our Revolution; for never were events greater, begun farther back in the past, better prepared, and so little foreseen."[1]

That the events of the Revolution were great, that they began far back in the past, no one will question; but is it true that they were little foreseen?

Rocquain showed how the Revolution was prepared and how certain Frenchmen during the middle of the eighteenth century feared and predicted it. Some time later, Champion called attention to the above statement of De Tocqueville and pointed out that the author was certainly in error as regards the foreseeing of the Revolution. Neither Rocquain nor Champion, however, mention the remarkable predictions made in 1758 by the Abbé Mably. In a work entitled, *Des droits et des devoirs du citoyen*, Mably shows himself a true prophet of revolution. He not only predicts a revolution, but shows in a logical and systematic way almost the exact means which were to bring it about and the steps which were to lead up to it.

It is my intention in this study to present briefly (1) the essentials of this work of Mably, so far as it is concerned with the Revolution, then (2) to relate in outline the events of 1787 and 1788—events which forced Louis XVI. to call the States General —in order to show how they agree with Mably's predictions, and (3) to close with a short account of the events of 1758, to make clear how it was possible for Mably, by a close study of this period, to gather the data necessary for his prediction.

[1] De Tocqueville, *L'ancien régime et la révolution*, 1.

MABLY'S PREDICTIONS

Mably, like others of his day, saw the financial distress of the government, and the difficulty with which it obtained new loans or taxes. On this question of finance, one body of men had for some time opposed the absolute power of the king.[1] This was the Parliament of Paris supported by the provincial parliaments and the people. It was the duty of the Parliament of Paris to register the royal edicts in order to give them legal form, a duty which was often construed into a very extended but indefinite right. Was the act of registration a mere formality in which Parliament was entirely passive, or could Parliament refuse to register and thus act as a real check upon the royal will? Parliament, during the eighteenth century, was determined to make the most of its position, and upon one question or another was in almost ceaseless conflict with the King and his ministers.[2] It was in this registrative function and this disposition of Parliament, taken in connection with the financial distress of the government, that Mably saw the elements of an approaching revolution.[3]

Mably believed that the King, encroaching more and more upon the prerogatives of Parliament, would force it to choose between a revolutionary rôle and utter effacement.[4] This being true, he thought Parliament would take advantage of the financial distress of the government to assure its own safety by an appeal to the nation. It was impossible, unsupported, to make a successful resistance to the King, and, although its positive interests were not identical with those of the nation, it would have common grounds with the latter in opposing despotism.[5] If, then, when the King should come, as he would certainly be forced to do sooner or later, with new tax edicts, Parliament should remonstrate, declaring that the people, already heavily burdened, were unable to bear any increase of the taxes, it would be certain of ultimate success, if it but showed a little more perseverance than upon a certain occasion a few years before.[6] This would be, in

[1] Rocquain, *L'esprit révolutionnaire avant la révolution*, livre VI.
[2] Ibid.
[3] Mably, *Des droits et des devoirs du citoyen*, 37–38.
[4] Ibid., 130.
[5] Mably, *Droits et devoirs*, 126.
[6] Ibid., 119.

effect, an assumption of representative authority, an assumption which Parliament would not be able to make good,[1] but rather than surrender its contention, and with it all but merely formal power, it would renounce its whole past history, and declare itself legally unable to consent to new taxes; that to obtain these the nation itself must be consulted.[2] This declaration would be followed by a demand that the States General be called together in order that the King might obtain what was necessary.[3] The king, however, would maintain that Parliament did have the power to register edicts establishing new taxes[4] and would finally force the registration in a *lit de justice*.[5] But Parliament would reply that such a registration was illegal and of non-effect and in so doing declare the laws superior to the King.

Such an act would produce a prodigious effect. The nation, seeing that Parliament stood as a barrier between itself and despotism, would rally to its support.[6] Even the nobility, having an old score to pay off against the ministers for past acts of despotism, would join in support of Parliament.[7] The provincial parliaments, having interests in common with that of Paris, would, of course, side with it.[8] This united opposition, led by Parliament, it would be impossible to resist. An army would be useless against a magistrature making no resistance in arms, and which the whole nation believed to be defending the laws rather than attempting to break them.[9] Finally, the King, unable to attain his ends because of the union of the entire nation against him, would be forced to call the States General. France, having thus been prepared by a long agitation, the States General would be in position to inaugurate real reforms,[10] to take advantage of the weakness of the King to establish constitutional liberty, and accomplish a revolution in the overthrow of the absolute monarchy.[11]

[1] Ibid., 126.
[2] Ibid., 119–120.
[3] Ibid., 120.
[4] Ibid., 120.
[5] Ibid.
[6] Ibid.
[7] Mably, *Droits et devoirs*, 120.
[8] Ibid., 121.
[9] Ibid., 122.
[10] Ibid., 132.
[11] Ibid., 132–133.

THE PARLIAMENTARY REVOLUTION OF 1787–1788

Early in the year 1786, Calonne found the royal treasury embarrassed by an enormous debt pressing for payment, while the total income of the government was insufficient to meet the annual expenses.[1] Under such conditions, it was evident that either the taxes must be increased or the expenses greatly reduced. But the mass of the people were already very heavily taxed, and to correct abuses and reduce expenses was a very difficult undertaking, one, in fact, in which Turgot had failed some time before.[2] In this predicament, Calonne determined to strike at the root of the evil and attempt to tax the privileged orders of the state which were paying very little toward the support of the government.

It was necessary, however, that measures of this kind should be registered by Parliament, a body largely composed of members of the privileged orders and hence directly affected by the proposed reforms. Owing to the past attitude of Parliament on financial measures, Calonne could expect only the most obstinate resistance from this quarter.[3] Instead of meeting this danger boldly, he took a roundabout way. Calling an Assembly of the Notables of the kingdom, he submitted his reform projects to them, hoping by their support to silence Parliament.[4] On account, however, of the great opposition to the minister at the court [5] and to the bad arrangement of certain details, but especially to the innate weakness of the plan which assumed that the privileged orders would surrender their advantages voluntarily, the whole affair ended in failure, and the government lost infinitely more than it gained. The plans were rejected,[6] Calonne was forced from office, and the financial distress of the government and its weakness in the face of opposition were made more apparent than ever. All the parliaments of the kingdom now understood each other. They had been encouraged rather than frightened, and had had an opportunity in the Assembly, where each one had been

[1] Chérest, *La chute de l'ancien régime*, I., 82.

[2] Gomel, *Les causes financières de la révolution française*, I., chs. 1–6. Chérest, I., 108.

[3] Droz, *Histoire du règne de Louis XVI.*, I., 345–347.

[4] Besenval, *Mémoires*, II., 204. Chérest, I., 110–111.

[5] Besenval, *Mémoires*, II., 204, 206, 211. Droz, I., 380.

[6] Droz, *Histoire du règne de Louis XVI.*, I., 391.

represented, to concert their opposition.[1] Lastly the attitude of the Assembly toward the reforms had shown the parliaments the temper of the Clergy and the Nobility and indicated the program to be followed.

About a month after the closing of the Assembly of the Notables, Calonne's successor, Brienne, submitted his reform measures to the Parliament of Paris for registration. Parliament at first, following in the steps of the Notables, assumed legislative functions by asking for a statement of the receipts and expenses of the government[2] (July 6), but having been answered by the King that this was a matter foreign to its duties, it gradually abandoned its position for one more fundamental. On the 16th of July, it declared that no power but that of the nation itself could impose a new and permanent impost,[3] and on July 24 it formally requested the King to assemble the States General.[4] On July 30 this request was repeated.

The government now determined to employ coercion. On August 6, in a *lit de justice*, it forced the registration of its edicts. Parliament protested that its duty required it to preserve the laws, and to protect the people against usurpation, and that the registration made in the *lit de justice* was illegal.[5] On the next day it declared the registration null and illegal.[6] For a week the government hesitated, but, as Parliament continued its opposition, it was finally sent into exile at Troyes.[7]

Parliament, however, was not intimidated by this severity, and its members, being able to pose as martyrs to the national cause, gained immense popularity. At Troyes, it continued its opposition by publishing and distributing decrees more violent than any previously passed.[8] Nevertheless, when a threatening decree of the King's Council was passed, the members paused to reflect.[9] Other motives, also, probably caused them to refrain

[1] Chérest, *La chute de l'ancien régime*, I., 131–132.
[2] Isambert, *Anciennes lois françaises*, XXVIII., 376–377.
[3] Chérest, I., 255–256.
[4] Ibid., I., 261.
[5] Moniteur, *Intro.*, 243–244.
[6] Chérest, *La chute de l'ancien régime*, I., 270.
[7] Ibid., I., 280.
[8] Ibid., I., 308–314.
[9] Ibid., I., 310–311.

from proceeding to extremities, for who could foretell the consequences of an opposition carried too far? Might not the whole structure of the ancient regime collapse and crush Parliament in the general ruin?[1] In spite of the radical faction, Parliament now yielded to negotiations with Brienne who had come to the end of his resources and accepted with almost feverish haste the conditions exacted by Parliament.[2] A compromise which, under the conditions, was discreditable to both parties was the result. Brienne abandoned the two important taxes which the King had announced as absolutely necessary and accepted a prorogation of the second *vingtième* levied upon all alike.[3] This was notoriously insufficient to meet the needs of the government, and the weakness that forced the minister to accept this compromise was made apparent.[4] On the other hand, the Parliament also took a backward step, for the *vingtième* levied in the manner agreed upon was, in reality, equivalent to a new tax, which Parliament had maintained it had no power to sanction.[5]

It was very apparent that the government was in immediate need of funds, and under the influence of the sobering reflections noticeable among the members of Parliament during the last days of their exile, reflections which had led to the compromise just discussed, D'Espremenil, on the part of Parliament, offered to register an immense loan, provided that the King would call the States General within a stated time.[6] This offer was eagerly accepted and the States General promised before 1792.[7] A royal session was held November 19, in which the edicts establishing these loans were registered. But the manner in which the King and his officers acted in presenting the edicts was so offensive that Parliament finally refused to recognize the registration. As if the government were playing the rôle of a conqueror, the King spoke in a harsh and rebuking way. The guard of the seals followed with a long speech in which he laid down the principles of the monarchy as understood by the absolutists, and, like the

[1] Ibid., I., 332.
[2] Ibid., I., 316–317.
[3] Chérest, *La chute de l'ancien régime*, I., 316–317.
[4] Weber, *Mémoires*, I., 187.
[5] Ibid., I., 187.
[6] Chérest, I., 330–331.
[7] Ibid., I., 346.

King, rebuked the members for demanding the calling of the States General, maintaining that this was a matter exclusively in the hands of the King.[1] Finally, after a long discussion, the King turned the royal session into a *lit de justice*, and ordered the edicts to be registered. Something of this sort had been anticipated, and the Duke of Orleans, who had been appointed for this purpose, protested against this act as illegal. "It is legal," replied the King, "because I wish it."[2] This was putting into practice what had just been announced in theory.

The King having withdrawn, Parliament continued in session and declared that it had taken no part in the registration because the vote had not been completed.[3] The next day the King tore this decree from the register and forbade its restoration.[4] The Duke of Orleans was exiled and two of the most violent of the opponents of the government were thrown into prison.[5] This last act was the cause of a new step on the part of Parliament. It now made an appeal to fundamental law. It declared that the King himself must obey the laws of justice; that these laws did not permit arbitrary punishment; that punishment in any case could be inflicted only through the proper judges, the Parliament, who are interpreters of the laws; that these laws were paramount to every other consideration, and that they could not be infringed without the gravest danger, and, hence, that the cause of the Duke of Orleans and the imprisoned magistrates was the cause of the entire nation.[6]

That this was an appeal for the support of the people is evident. It should be remembered that throughout this whole struggle with Parliament the latter found in public opinion its real power. Parliament very early recognized this and began to court popular favor, which was readily given. In some instances, during the later period of the struggle the King's orders remained unexecuted on account of the active opposition of the mob, but Parliament made public opinion an absolutely fatal weapon in discrediting the government with the people and thus interfering with the

[1] Moniteur, *Intro.*, 263.
[2] Chérest, *La chute de l'ancien régime*, I., 357.
[3] Moniteur, *Intro.*, 368.
[4] Ibid., 268–269.
[5] Chérest, I., 361.
[6] Moniteur, *Intro.*, 271–272.

borrowing of money and the collection of taxes. It was the impossibility of obtaining the funds necessary to carry on the government which forced the King to call the States General.

Soon after the announcement of the general principles just cited, Parliament condemned the use of the *lettre de cachet* as illegal and contrary to public and natural rights[1] (January 4, 1788). On April 11 followed a positive denial of the absolute supremacy of the King's will,[2] and on May 3 came a formal declaration of the principles of the monarchy, forming a counterpiece to the principles of the monarchy laid down by Lamoignon in the royal session of November 19, 1787.[3] This declaration was little more than a *résumé* of the contentions previously made, but it served to show clearly the wide gap existing between the government and its Parliament and the difficulty of a compromise.

At the close of 1787, or at the beginning of 1788, the government seems to have reached the conclusion that nothing short of entire political destruction would silence Parliament.[4] To accomplish this destruction a *coup d' état* was planned by which the power of registration was to be taken from Parliament and lodged in a *Cour plénière*, composed of members chosen by the King.[5] The edict for the establishment of this court, accompanied by a number of other edicts, was registered in all the parliaments of the kingdom on the 8th of May, but the Parliament of Paris, having learned beforehand the essentials of this plan, warned the other parliaments so that a united opposition flamed up against the government.[6] In spite of this opposition, however, which in some places amounted almost to rebellion, the parliaments as official bodies were silenced by an order to discontinue their meetings. On the other hand, the *Cour plénière* was never formed[7] and would have been useless had it been formed, because it would not have possessed the public confidence necessary to make its registration of value to the government.

The revolution was now precipitated because the credit and the

[1] Chérest, *La chute de l'ancien régime*, I., 379–380.
[2] Moniteur, *Intro.*, 280.
[3] Ibid., 284–285.
[4] Droz., *Histoire du règne de Louis XVI.*, II., 39–40.
[5] Isambert, *Anciennes lois françaises*, XXVIII., 560–567.
[6] Droz., II., 51.
[7] Chérest, *La chute de l'ancien régime*, I., 501.

resources of the government were utterly exhausted. An attempt in June to obtain money from the clergy failed and called forth bitter remonstrances against the treatment of the parliaments.[1] Despite every effort, Brienne was forced, August 16, to declare, in effect, a partial bankruptcy.[2]

Meanwhile the States General had been announced for the 1st of May, 1789, and the question of their composition and manner of voting had been raised.[3] What should be the power of the Third Estate? Should it have a double representation and should the voting be by "head" or by "order," i. e., should the Third Estate be given sufficient power to reform abuses existing in the form of exemptions and privileges in matters of taxation, or should the old form of organization and procedure be retained, and each order hold an absolute veto upon the acts of the others? Before these questions were settled, Brienne was replaced by Necker. Necker, fearing to take a decisive step, declined to decide for the government, recalled the Assembly of the Notables, and submitted the questions to them.[4] The Assembly declared against the pretensions of the Third Estate.[5] This, naturally, did not satisfy the Third Estate which had entered the contest aggressively when the States General was announced. To compromise opinions, evidently, the government disregarded the advice of the Notables, at least in part, and gave the Third Estate a representation equal to that of the other two orders combined. It retained, however, the vote by order which made the first concession of little or no value, because the other orders would still be able to block all reforms.[6] Nevertheless, the Third Estate later forced a vote by head, and with this accomplished put themselves in position to enforce their demands and to overthrow the absolute monarchy.

[1] Moniteur, *Intro.*, 380–394.

[2] Ibid., 360–361.

[3] Isambert, *Anciennes lois françaises*, XXVIII., 601–604. Moniteur, *Intro.*, 394–395.

[4] Chérest, *La chute de l'ancien régime*, II., 179–180.

[5] Ibid., II., 196. Moniteur, *Intro.*, 411–497.

[6] Moniteur, *Intro.*, 500–509.

THE REVOLUTION BEFORE 1758

A comparison of the prediction made by Mably in 1758 with the events of 1787–1788 will show how closely the two agree in all essential points. The question now to be considered is how it was possible to make such predictions in 1758. The answer is found in the events which preceded this date. Even a very superficial study of the first half of the eighteenth century reveals the fact that the revolutionary forces were then already in full operation. It was in what passed under his own eyes that Mably saw what the future was likely to have in store for France.

Champion, to whom I have already referred in my introduction, says, "A revolution was inevitable. Everyone expected it, nearly everyone wished it, commencing with those who were later to rue and to calumniate it; yet very few people suspected what it was going to be."[1] This generalization applies to a period as remote as the middle of the eighteenth century. During the last years of the reign of Louis XIV. a struggle over the famous Constitution *Unigenitus* began, and for nearly fifty years kept France in almost continual agitation. This Constitution, which the higher Clergy attempted to force upon France, was very obnoxious to much the greater portion of the nation which, led by Parliament, strongly resisted it. When the national finances, already in a bad state at the close of the preceding reign, were more and more disordered by the extravagances of Louis XV. in his court expenses and in the wars of the period, the continual increase of the taxes added another cause for trouble. In the agitation over these two subjects, the royal authority was slowly brought into contempt because it was so often disregarded, and because it was evident that it could not be enforced.[2]

The government having all along sided rather with the Clergy than with the mass of the nation in the affair of the Constitution, things were brought to a crisis early in 1752, when Parliament determined to take an aggressive part against the Constitution. Those of the Clergy who had accepted the Constitution had for a long time attempted to force it upon the people by withholding the sacraments from those who refused to receive it as a

[1] Champion, *Esprit de la révolution française*, 69.

[2] An account of these struggles and conditions is found in Rocquain, *L'esprit révolutionnaire avant la révolution.*

rule of faith. On April 18 Parliament passed a decree forbidding this practice under pain of rigorous punishment.[1] This, as a legislative act, was a violent encroachment upon the royal authority, but as the people received it with great rejoicing, the government feared to condemn it.[2] The often-repeated order of the government for general silence upon the Constitution was disregarded as usual; agitation increased rather than diminished, and Parliament became bolder than ever. On November 21, 1752, the government condemned the decree of April 18, as encroaching upon the legislative power which belonged exclusively to the King, but as it left untouched Parliament's claim to punish curés who were guilty of misconduct in their ministry, and as it did not annul the prosecutions ordered in virtue of the decree, it was only a half measure at best, while the very fact that the government had waited so long before taking even this step was a confession that it had feared to act when Parliament had passed the decree. [3] This satisfied neither party, and the quarrel became more violent than ever. The Clergy continued to refuse the sacraments, while Parliament increased its rigors against them. Finally, February 22, 1753, the King ordered Parliament on pain of disobedience to cease meddling in matters concerning the administration of the sacraments.[4] Parliament, while continuing its interference, refused to register the order of the King until it should have made some *grandes remonstrances*.[5] These remonstrances the King refused to receive until his orders had been registered. On Parliament refusing to subscribe to this condition, it was sent into exile.[6]

This did not subdue Parliament. Never had its credit been so high in France. Felicitations came in from all sides. The provincial parliaments modeled their conduct after that of Paris, being, however, more violent.[7] The parliaments as forming one body now began to realize their power. In a mémoire of some exiled members at Bourges and Poitiers, it was stated that the

[1] Isambert, *Anciennes lois françaises*, XXII., 251–252.
[2] Rocquain, 156.
[3] Rocquain, "*L'esprit révolutionnaire avant la révolution*," 164.
[4] Ibid., 166.
[5] Ibid., 166–168.
[6] Ibid., 169.
[7] D'Argenson, *Mémoires*, VIII., 38, IX., 372.

parliaments united would be stronger than any other power in France. This was followed by a boast that, although the King might have 100,000 soldiers, the parliaments had all hearts, good will, and esteem.[1] But, what was more important than everything else, the general opinion was establishing itself that "the nation is above kings,"[2] an opinion which struck at the very foundation of absolutism. Revolution in church and state began to be talked of, and Rocquain asserts that it was about to take place in the middle of the year 1754, when the government suddenly changed front and recalled Parliament.[3]

In this struggle Parliament had really scored a victory because on its recall the King charged it with the very work it had undertaken in its legislative decree of April 18, 1752—the decree which led to its exile.[4] It is important to notice that the defeat of the government did not escape the notice of contemporaries. Both D'Argenson[5] and Barbier[6] entered in their journals that Parliament had won its point.

Although Parliament had hesitated to accept the conditions imposed by the King in its recall, favorable as they were, and had even dared to modify them,[7] the greatest harmony soon followed between it and the King. The Clergy were treated with great severity by King and Parliament in conjunction.[8] But this peace was not destined to last long. When a quarrel broke out between the Grand Council and Parliament concerning the powers of the latter, the King sent a declaration to Parliament in which he seemed to attribute the powers of a sovereign court to the Grand Council. Parliament suspended the registration of this declaration until it should have made its remonstrances,[9] and the quarrel between it and the King was on again. Parliament now went even farther into the legislative field than in 1752, for on April 6, 1756, it passed a decree which defined the powers of the

[1] Ibid., VIII., 78.
[2] D'Argenson, *Mémoires*, VIII., 153.
[3] Rocquain, *L'esprit révolutionnaire avant la révolution*, 180, 184.
[4] Isambert, *Anciennes lois françaises*, XXII., 260–261.
[5] D'Argenson, *Mémoires*, VIII., 343–344.
[6] Barbier, *Journal historique et anecdotique du règne de Louis XV.*, IV., 39.
[7] Ibid., IV., 38–39.
[8] Rocquain, 185–191.
[9] Ibid., 191.

Grand Council, thus, in effect, setting aside the declaration of the King.[1]

Meanwhile, the strife over the Constitution continued, and excitement in the public ran very high. In May the Seven Years' War broke out, and new taxes were needed. The King ordered the Parliament to register an edict establishing a second *vingtième*. Parliament hesitated until the King forced the registration in a *lit de justice*—a registration which Parliament resisted by new remonstrances. Finally, in the midst of increasing discontent and confusion, the King on December 13, 1756, in a *lit de justice*, forced the registration of edicts which destroyed the old organization of Parliament and, through this, its power of resistance. Nearly all the members at once resigned, and the King was without a parliament, which previous experience had shown to be indispensable to him.[2]

Soon after this, an attempt was made to assassinate the King, which so frightened him that he treated both the Clergy and the different parliaments with the greatest severity.[3] After several months, however, it was found necessary to restore Parliament, and the members received back their resignations.[4] Here again the Parliament triumphed, for, while the provisions of the edicts registered in the *lit de justice* of December 13 were not expressly revoked, they remained unexecuted.[5]

Having now shown how the government was upon two distinct occasions forced to grant the demands of Parliament supported by public opinion, the next point is to show why it was impossible for the King to enforce his will by destroying the parliaments altogether. This could not be done because the people looked upon the parliaments as the champions of their own cause. This opinion affected the King in two ways. In the first place, excitement ran so high on several occasions that actual violence was

[1] Rocquain, *L'esprit révolutionnaire avant la révolution*, 194.

[2] An account of this affair is found in Rocquain, 197–201.

[3] Ibid., 202–204.

[4] As usual it was the need of money that forced the government to restore Parliament. Soon after the *lit de justice* of December 13, D'Argenson wrote, "Il n'y a pas un écu au trésor royal. L'on a, dit-on, sept à huit nouveaux édits bursaux tout prêts pour secourir les finances, mais le diable est qu'il faut l'enregistrement du parlement," IX., 372. See also 378.

[5] Rocquain, 205.

feared, and, to make matters exceedingly grave in such cases, the fidelity of the soldiers was doubtful should an insurrection take place.[1] Secondly, the public distrusted the government loans unless sanctioned by the Parliament of Paris, and resisted the collection of those taxes not agreed to by Parliament. This made the Parliament absolutely indispensable to the King and constituted its power and its safety. That this was the weak place in the government's armor was perfectly clear to D'Argenson at the time. On April 18, 1752, he wrote, "I have been assured that the government has need of Parliament for registering a new loan; for, to whatever side the *controleur général* of the finances turns, he finds every door closed, and that he is unable to borrow from anyone unless Parliament puts its seal upon the transaction."[2] Thus also Barbier in 1754, referring to the government's need of Parliament, wrote, "This may be to register an edict for life annuities or for a lottery, in order to borrow a good sum of money. Although this registration, in reality, gives no security to the public, the nation, by principle and custom, believes to find a security in it, and this suffices. One will not bring his money to the royal treasury under any other form of registration, be it by the royal chamber, the chamber of accounts, or even by the council of states."[3]

The power of Parliament to force the government to grant its demands has now been shown. What was there in the period preceding Mably's writing to show that there was a disposition to declare the supremacy of the nation in matters of taxation and to call for a meeting of the States General in consequence? As early as December, 1750, D'Argenson wrote that it was said in Paris that the Clergy, pushed to extremes, were about to declare that the King could not lay an impost arbitrarily, and to call for the States General. Commenting upon this, he says, "Notice in what style the remonstrances of the parliaments and of the Estates have appeared upon the *vingtième;* these *procureur-généraux* of the parliaments, these *syndics d'etats*, all these will become the great men I have referred to; all the nation will take fire, the

[1] D'Argenson, *Mémoires*, VIII., 247–248.

[2] Ibid., VII., 203.

[3] Barbier, *Journal historique et anecdotique du règne de Louis XV.*, IV., 22.

Nobility will join themselves to the Clergy, then the Third Estate; and if the necessity of assembling the States General result there will be matters of finance to regulate and later the demands for money; these Estates will not be assembled in vain. Let one take care, they will be very serious."[1] This is not an isolated reference. In the violent encounters between the King and Parliament from 1752–1757, the idea of the supremacy of the nation, and the necessity of calling the States General as a result of the resistance is again and again referred to by D'Argenson.

To sum up, then, we may say that Mably's predictions were little if anything more than could have been found in a careful analysis of the forces which he saw in operation during his own time. He saw existing in France a condition of general dissatisfaction and unrest; political questions had been discussed for a long time and the rights of absolutism denied. More than that, absolutism had been continually defeated in its attempt to silence either the Clergy or the parliaments, and to prevent the parliaments from assuming legislative power. Finally, it had failed to make itself financially independent, a circumstance which left it perpetually exposed to an attack which it could not withstand. But while all this is true, while the literature of the half century previous to 1789 is full of prophetic utterances, no other writer predicted the outcome of the whole matter in the definite and comprehensive way that characterizes the work of the Abbé Mably, a true prophet of revolution.

[1] D'Argenson, *Mémoires*, VI., 318–320.

# ACHROMATIC POLARIZATION WITH CRYSTALLINE PLATES*

BY E. J. RENDTORFF, M.S., FELLOW IN PHYSICS

If a train of waves, polarized at a definite angle to the principal axis of a crystalline plate, pass perpendicularly through the same, the retardation of the component light-waves is a function of the thickness of the crystal, the differential dispersion, and the absolute wave-length of the light. By crossing two or more such plates, the difference of the resultant retardations may be made a minimum. Such a system would approach achromatism.

Consider a crystalline wedge, of thickness $D$, and indices of refraction $u_e$ and $u_o$, to be placed under a polariscope, at an angle of 45° to the plane of polarization of any monochromatic light, such as that of sodium, the Nicols being crossed. A series of equidistant black bands on a yellow field appears. If white light be employed, a series of adjacent spectra is produced, which overlap more and more as the wedge is thickened, finally producing white light.

The relative path retardation for any one crystal is:

$$d = D(u_e - u_o) \tag{1}$$

The order of this plate is:

$$N = \frac{D(u_e - u_o)}{\lambda} \tag{2}$$

From equation (2) it will be seen that the term "order of a plate" is not specific, unless the period of the monochromatic light, for which the order has been determined, is stated.

If three or more crystals be united so as to form a system, their order for any period is:

$$N = \frac{D_1(u_e - u_o)}{\lambda} \pm \frac{D_2(u'_e - u'_o)}{\lambda} \pm \frac{D_3(u''_e - u''_o)}{\lambda} \pm \text{- - -} \tag{3}$$

The negative sign is used for those crystals that are in a subtractive, and the positive sign for those that are in an additive position, with respect to any one crystal of the system taken as a standard of reference.

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Such a system presents a maximum achromatism when:—

$$\frac{\delta N}{\delta\lambda}=\frac{\delta}{\delta\lambda}\left\{\frac{D_1(u_e-u_o)}{\lambda}\pm\frac{D_2(u'_e-u'_o)}{\lambda}\pm\frac{D_3(u''_e-u''_o)}{\lambda}\pm\right.$$
$$\left.\frac{D_4(u'''_e-u'''_o)}{\lambda}\pm\text{- - -}\right\}=0 \qquad (4)$$

In a system of two plates, with the principal axes crossed, the condition for achromatism is consequently that:

$$\frac{\delta}{\delta\lambda}\left\{\frac{D_1(u_e-u_o)}{\lambda}\pm\frac{D_2(u'_e-u'_o)}{\lambda}\right\}=0 \quad \text{or}$$
$$\frac{\delta N_1}{\delta\lambda}=\frac{\delta N_2}{\delta\lambda} \qquad (5)$$

If a crystalline wedge or plate be placed under a polariscope so that the principal axis of the crystal makes an angle of 45° with the plane of polarization of incident white light, the Nicols being crossed, and examined with a spectroscope, a series of sharply defined, black interference bands will be seen to cross the spectrum, as first discovered by Müller. These black bands occur where $\frac{D(u_e-u_o)}{\lambda}$ is an exact multiple of $\lambda$.

If a black band occur at the position of the *Na* line, of the order $\frac{D_1(u_e-u_o)}{\lambda}=N$, the two adjacent bands will be found where

$$\frac{D_1(u_e-u_o)}{\lambda}=N+1 \qquad \text{and}$$
$$\frac{D_1(u_e-u_o)}{\lambda}=N-1.$$

The disposition of these lines in the spectrum is dependent upon the actual differential dispersion of the crystal for different periods. If two crystals of relative orders $N_1$ and $N_2$ have these bands similarly placed, band for band, they will produce a perfectly achromatic system, when their principal axes are crossed, as equation (5) shows.

In general, such a similar disposition of the bands does not obtain, but there will always be certain relative orders which give the best coincidence of these bands, either between two certain periods, or throughout the entire visible spectrum.

To determine these best relative orders contiguous interference spectra of two crystals were obtained and the disposition of the bands altered by varying the thickness of the crystalline wedges, until the best coincidences, on either side of the *Na* lines, at equal

periodic distances from them, were obtained. The cross-hair of the spectrometer was then adjusted so as to coincide with the position midway between the *Na* lines, and the wedges altered in thickness by moving them past the collimator slit by means of a screw arrangement.

As the crystal is changed in thickness the interference bands move across the spectrum, and the number shifted past the cross-hair is counted. If the differential dispersion be normal and the crystal be increased in thickness, the bands move toward the red; if diminished, toward the violet end of the spectrum. For every order that the crystal is altered in thickness there is a shifting of one band, in the spectrum, past that portion of it representing the period for which the crystal has been changed by one order. If, for a definite position of the crystalline wedge, an interference band coincides with the *Na* line, and $N$ bands shift past that portion of the spectrum, while the wedge is diminished to the zero order at its position opposite the collimator slit, then, in its original position the wedge was of the $N^{\text{th}}$ order for *Na* light.

It is sometimes impossible to determine when the last band disappears. To obviate this uncertainty the following methods may be utilized. Let us assume two adjoining spectra in exact contact, whose interference bands present a coincidence between certain periods. Diminish the thickness of one wedge until two bands, in the unaltered, coincide with one in the altered spectrum throughout the zone of the previous coincidence. If $N$ bands have passed the *Na* line $2N$ will be the order of the crystal, for monochromatic *Na* light, in its original position. Furthermore, if the wedge be increased in thickness until, finally, $B$ bands in the altered correspond to one in the unaltered spectrum, the wedge, in its original position was of the order $\frac{B}{B-1}N$ where $N$ denotes the number of bands shifted past the *Na* line.

The order of a crystal for any wave-length can thus be accurately determined even when $B=24$, as deduced theoretically by Prof. D. B. Brace (*Phil. Mag.*, p. 345, Oct., 1899).

If the adjoining interference spectra are produced by the same crystal, one in the shape of a wedge and the other a plane plate, an exact coincidence is always possible, throughout the entire visible spectrum, and the order of the plate may be exactly determined, even when this order is several thousands.

The apparatus was arranged as shown diagrammatically in fig. 1. *N* represents the Nicols prisms, which are crossed at an angle of 45° to the principal axes of the crystalline wedges *B*, *B*. *A*, *A* are smaller wedges of the same angle, and *C*, *C* plane plates used to obtain higher orders than are possible with the wedges alone. *L* is a platform, movable by means of the screw *D*, on which the wedges *B* are mounted. *E* is a totally reflecting prism, *F* the collimating lens, and *G* a flint glass prism placed at the angle of minimum deviation for *Na* light. *HI* is the observing telescope, and *K* a photographic scale placed at the principal focal length from the achromatic lens *J*.

The collimator slits *S*, *S* were ruled on silvered glass with a sharp knife. These slits should be close to the wedges, through which the light passes normal to their optic axes.

The apparatus is so adjusted that the two spectra are contiguous, with their Fraunhofer lines in exact coincidence, and no parallax between the interference bands and the scale.

The wedges were now adjusted until the coincidence, at equal periods on either side of the *Na* line, was the best obtainable. The cross-hair was then set midway between the $D_1$ and $D_2$ lines, where coincident interference bands were always formed, and the orders of the two crystals determined as previously described.

The crystals used were Iceland spar, selenite, mica, and quartz. The best coincidences were obtained for the

40th order for *Na* light of mica when combined with the 35th order of selenite;

45th order for *Na* light of mica when combined with the 40th order of quartz;

222d order for *Na* light of quartz when combined with the 212th order of Iceland spar;

210th order for *Na* light of selenite when combined with the 198th order of Iceland spar;

606th order for *Na* light of selenite when combined with the 594th order of quartz.

From the orders obtained for mica when combined with quartz and selenite, it follows that the 64th order of quartz, for *Na* light, produces the best achromatism when combined with the 63d order of selenite. These relative orders give a fair coincidence of bands in the red, but leave the green uncompensated.

The orders 101 selenite to 99 quartz give a far better compensation throughout the visible spectrum, especially between the yellow and blue, but achromatise poorly in the red. With this combination of crystals, as also with selenite and Iceland spar, it is possible to achromatise for certain periods only. Mica and selenite, as well as Iceland spar and quartz, give a good coincidence of bands throughout the entire spectrum.

In order to study the disposition of the interference bands for various orders of selenite and quartz, the refracting prism *G*, fig. 1, was replaced by a plane grating. By means of an achromatic lens, *K*, fig. 2, a scale, *M*, graduated in fifth millimeters, was projected into the telescope, *HI*, and the position of the bands plotted.

Fig. 3 shows that orders 65 selenite and 66 quartz achromatise better in the red than orders 67 selenite and 66 quartz, but far poorer in the green and blue. The last-named orders give a good coincidence between the yellow and blue where the light is intense.

Let us assume that two crystals of the $N_1$ and $N_2$ orders present a maximum achromatism. If these crystals of the orders $\frac{N_1}{4(N_1 - N_2)}$ and $\frac{N_2}{4(N_1 - N_2)}$ be crossed, an achromatic quarter-wave plate results. The orders 2 of mica and $1\frac{3}{4}$ of selenite, for *Na* light, were used for one of these plates. A Fresnel rhomb was placed at an angle of 45° to the plane of polarization of a polarizer, and, with Nicols crossed, the achromatic plate was placed above the rhomb in such a position as to give a minimum illumination. The light, passed through the analyzer, was then examined with a spectroscope. Total darkness existed in the neighborhood of the *Na* line, with a continuous increase of illumination toward the red and violet, showing that these colors had not been compensated for perfectly. When placed under a polariscope the achromatic plate showed very little change of color on revolving the analyzer. It consequently approximated the ideal achromatic condition.

Let us assume we have two crystals, such as Iceland spar and quartz, of the 212$^{th}$ and 222$^{d}$ order for *Na* light, respectively. Let us furthermore assume that the interference bands produced by them coincide at the *Na* lines, and that the last visible red band

in the quartz extends $\frac{1}{10}$ th band beyond the corresponding one in the selenite, while a certain violet band in the selenite spectrum extends a similar distance beyond the corresponding quartz band. Orders of 5.55 for quartz and 5.30 for selenite will then make a plate whose phase-retardations will be 90° 25′ for the extreme red, 90° for yellow, and 89° 35′ for the violet rays.

When a crystal with normal differential dispersion is examined with a refracting prism, the black interference bands are furthest apart in the violet and narrowest in the red; but with a normal spectrum the reverse is observed, which agrees with the theory of the distribution of these bands.

The curves in fig. 4 represent the image of the scale as abscissae, and the number of the black interference bands, in the irrational refraction spectrum, as ordinates. The band coinciding with the *Na* line, or the one immediately toward the red end of the spectrum from this line, is represented as the zero band. The orders used were 75 for mica, 88.5 for Iceland spar, 187 for selenite, and 199 for quartz.

In conclusion, the author desires to thank Professor Brace for many valuable suggestions that enabled him to carry out this work.

Physical Laboratory,
University of Nebraska,
March, 1900.

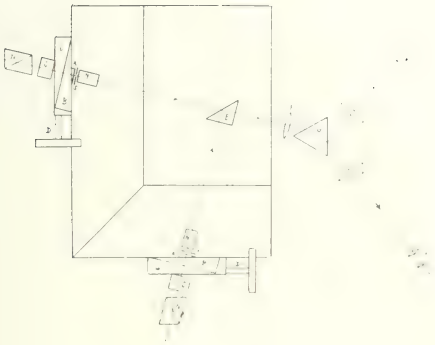

FIG. 1.

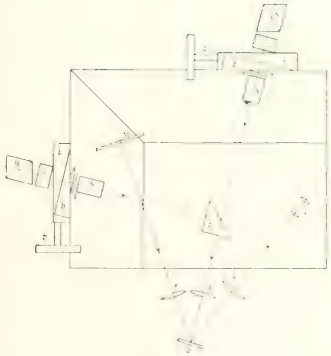

FIG. 2.

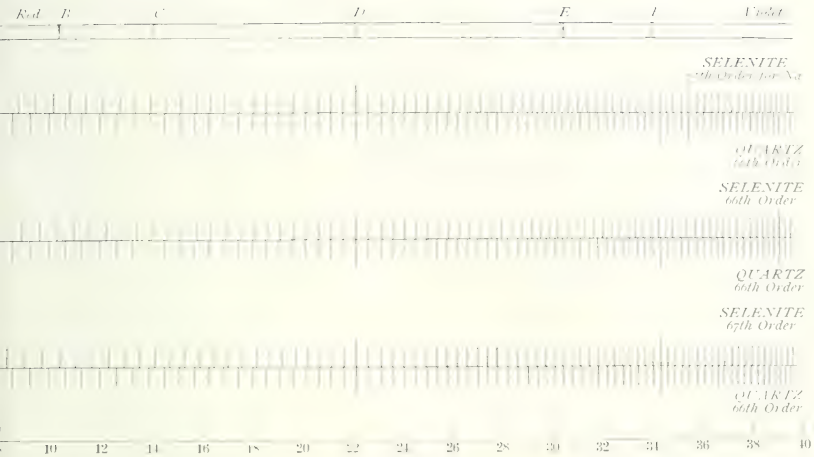
Red
B
C
D
E
F
Violet
SELENITE
67th Order for Na
QUARTZ
66th Order
SELENITE
66th Order
QUARTZ
65th Order
SELENITE
67th Order
QUARTZ
66th Order
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40

FIG. 3.

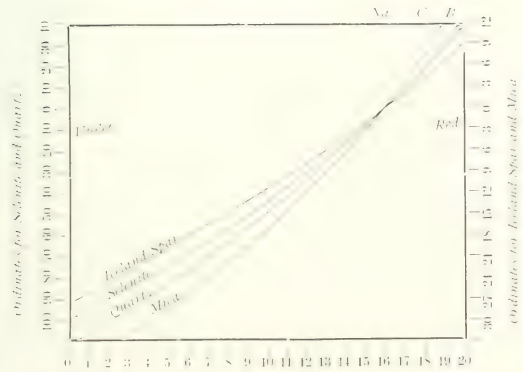
Na
C
F
Violet
Red
Iceland Spar
Selenite
Quartz
Mica
Ordinates for Selenite and Quartz.
Ordinates for Iceland Spar and Mica
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

FIG. 4.

# THE CARTESIAN OVAL

BY CARL CHRISTIAN ENGBERG, PH.D.

## THE AUXILIARY PARABOLA

1. If, in the equation of a parabola,

$$y^2-2Ay-2Bx+C^2=0 \qquad (A)$$

we substitute $\rho$ for $y$, we obtain the equation of a Cartesian. Hence, if the feet of the $y$ ordinates be gathered at the origin, while the extremities slide along the original positions of the ordinates, the locus of the extremities will be a Cartesian, or, rather, conjugate parts of a complete Cartesian. The limiting axial points correspond to $x=\pm y$ in the parabola.

2. In mixed coordinates the equation becomes

$$\rho^2-2A\rho-2Bx+C^2=0 \qquad (B)$$

In (A) $A$ represents the distance of the diameter, which is the axis of $x$, from the axis of the parabola; $B$ is the semilatus rectum, and $\pm C$ the ordinates of the points of tangency of the tangents from the origin, while

$$x=-\frac{C^2-A^2}{2B}$$

is the equation of the tangent at the vertex.

Considering now the Cartesian and the relation which it bears to the parabola, we see that—

The tangent at the vertex of the parabola becomes the double tangent of the Cartesian;

$A$ is the distance of the points of contact of the double tangent from the focus pole;

$C$ is the length of the tangents from the focus pole to the Cartesian.

3. Since the parabola touches the line at infinity, the points of tangency become the cuspidal points at infinity of the Cartesian, i. e., the circular points. It follows that the distance of the circular points from the origin is $i$ times the infinite ordinate of the parabola. If we consider the triangle formed by the cuspidal tangent and the coordinates of either of the circular points, we have

$$(x_\infty - x')^2 + (iy'_\infty)^2 = r^2. \qquad (C)$$

As the infinite points of the auxiliary parabola satisfy the equation $y^2 = 2Bx$,

(C) becomes

$$(x_\infty - x')^2 + (iy'_\infty)^2 = -2Bx_\infty.$$

Now the coordinates of the circular points have the ratio $i$, i. e., the infinities in the above equation have the ratio unity; whence this equation reduces to

$$-2x'x_\infty + x'^2 = -2Bx_\infty = -2x'x_\infty.$$

$$\therefore x' = B.$$

As a complete Cartesian is obtained from the two parabolas

$$y^2 \pm 2Ay - 2Bx + C^2 = 0,$$

it is evident that the tangents to the Cartesian from the circular points at infinity are equidistant respectively from the corresponding tangents to the parabolas; whence it follows that the line joining the foci of the parabolas cuts the axis of the Cartesian in a point equidistant from the two axial foci not at the origin, namely in the point

$$( (B^2 + C^2 - A^2)/2B, 0).$$

Thus we see that the length of the semilatus rectum of the auxiliary parabola gives the cuspo-focus of the Cartesian, and its abscissa the mean of the two axial single foci not at the origin.

4. Considering the method of derivation of the Cartesian from the parabola, it is clear that, with the conditions in the margin below, the statements in the text follow.

| | |
|---|---|
| 1. $C > \lvert A - B \rvert$ | One of the ovals is imaginary, and hence the parabola gives only half an oval. |
| 2. $A < B$<br>$B - A > C$ | We have two half ovals on different sides of the axis, and the origin is the external focus. |
| 3. $A > B$<br>$A - B > C$ | We have two half ovals on the same side of the axis, and the origin is the extreme interior focus. |
| 4. $C^2 < 0$ | The origin is now within the parabola, and we get two half ovals on different sides of the axis. The origin is the middle focus. |
| 5. $C^2 = (A - B)^2$ | We get a Limçon: with a node if $A > B$, and with a conjugate point if $A < B$. |

| | |
|---|---|
| 6. $C=0$ | The Cartesian in this case also reduces to a |
| $A-B$ is not 0 | Limaçon. |
| 7. $C^2=(A+B)^2$ | (B) represents a point. |
| 8. $A=0$ | The Cartesian reduces to a circle. |

5. To see the geometrical meaning of the inequality $C \lesseqgtr |A-B|$ draw the tangent to the parabola at the extremity of the latus rectum nearest the axis of $x$. The ordinate of this point is evidently $|A-B|$. If, then, the origin and the parabola lie on the same side of the $x$ intercept of this tangent, $C < |A-B|$, and we get two ovals; but if they lie on different sides, $C > |A-B|$, and the inner oval is imaginary. Between $C=|A-B|$ and $C=A+B$ the outer oval is always real, at the latter value shrinking into a point.

6. $$y^2-2Ay-2Bx+C^2-0,$$

where $C$ is constant and $A$, $B$ vary in such a manner that $(C^2+B^2-A^2)/2B$ is constant, represents a system of parabolas, such that the points of contact of the tangents from the origin lie on one or the other of the lines $y=\pm C$,
while the foci lie on the line

$$x=\frac{C^2+B^2-A^2}{2B}$$

Consequently, this system of parabolas gives a system of triconfocal Cartesians, of which the axial circle through the single axial foci not at the origin forms the limiting case. From this it follows that the length of the tangent from the origin to this circle is $C$, and that the product of the distances from the origin of the two axial foci not at the origin is $C^2$.

Thus, knowing the mean and the product of these distances, we can easily find the other two foci, if the equation of the Cartesian and one focus be given.

7. Half the distance between the two single axial foci not at the origin is

$$\sqrt{A^4+B^4+C^4-2B^2C^2-2C^2A^2-2A^2B^2}/2B,$$

and half the distance between their anti-foci is $i$ times this amount. Therefore these anti-foci lie on a circle, center at the focus-pole, and passing through the points of contact of the tangents from the origin.

Similarly it may be shown that a circle, center the cuspo-focus,

and tangent to the axis of the auxiliary parabola will also pass through these points. It will be noticed that when one of the ovals is imaginary, the two single axial foci not at the origin are imaginary, but that their anti-foci are real. This is easily seen from the relations

$$C^2>(A-B)^2, \quad x=\frac{C^2+B^2-A^2}{2B}$$

8. By means of the auxiliary parabola many properties of the Cartesian oval may be obtained. I give three examples:

(1) Through the extremities of any focal chord of a Cartesian are drawn conics having the focus for a common focus. Of this doubly infinite system of conics there is a singly infinite system, such that, if one of their points of intersection in pairs lie on a fixed Cartesian, all of them do.

(2) Two conics having one of the foci of a Cartesian for a common focus are tangent to the Cartesian; if one of their points of intersection lie on a fixed Cartesian, all of them do.

(3) The locus of the middle point of a focal chord of a Cartesian is another Cartesian having the given focus for a focus.

NORMALS

9. Let the equation of an axial parabola tangent to the auxiliary parabola be $y^2-2Rx+S^2=0$. As the two parabolas touch, the normals at the point of tangency will coincide. Bearing in mind that the projection on the axis of a normal to a parabola equals the semi-latus rectum, we have from the figure:

$$\frac{PM}{PN}=\frac{MG'''}{NG''} \text{ or } \frac{\rho}{\rho-A}=\frac{R}{B};$$

whence

$$\frac{\rho}{A}=\frac{R}{R-B}.$$

Now draw through the cuspo-focus of the Cartesian a line $KD$, parallel to the vector of $P^1$, cutting the circle; center the cuspo-focus and radius $A$ in $D$. Let the line joining $P^1$ and $D$ cut the axis of the Cartesian in $G^1$. The above equalities then evidently give $fG^1=R$.

As the two parabolas touch at $P$, the Cartesian and the circle derived from them must touch at $P^1$; whence $P^1\,G^1$ is a radius

of the circle and normal to the Cartesian in $P^1$. Thus the distance from the focus pole to the foot of a normal to a Cartesian is equal to the corresponding subnormal of the auxiliary parabola.

10. If $P$ be the extremity of the latus rectum, the normal at $P$ will make an angle of 45° with the axis, whence

$$fP^1=PM=MG'''=fG^1,$$

with similar relations for the inner oval. Now the intersections of the latus rectum with the Cartesian are the vertices, relative to the axis of the anti-foci, of the axial foci not at the origin. Hence, for these points, the radius vector and the abscissa of the foot of the normal are equal. It is evident that in this case the radii vectores are equal to $|A\pm B|$. Therefore, if, with the focus pole as center, we describe circles whose radii are $|A\pm B|$, the chords joining the intersections with the corresponding ovals to the corresponding intersections with the axis are the normals at the extra-axial vertices.

11. The subnormal is

$$R-x=\frac{\rho^3-3A\rho^2+(C^2+2A^2-2B^2)\rho-AC^2}{2B(\rho-A)}$$

This gives us, in general, three subnormals of the same length. It is easily seen that $C^2/2B$ is the length of the subnormal of the evanescent normal whose foot is the focus pole. Mr. Roberts has also shown[1] that there are three normals of a given length, the mean of the abscissae of their feet being the mean of the single axial foci not at the origin.

FOCI

12. In the number of the *Annals* which appeared in June, 1898, I showed that the so-called triple focus of a Cartesian oval is in reality only a double focus. But as it differs in nature from the ordinary double focus, I have decided to call it the "cuspo-focus" of the Cartesian, and the corresponding tangents, the "cuspo-tangents," instead of "triple-tangents." It is to be hoped that some one will, before long, invent terms which are both expressive of the facts and also capable of extension, to take the places of those used above, which are expressive, but not extensive.

I venture here to make the statement that what has, in the

[1] *Proc. London Math. Soc.*, III., 120.

paper just referred to, been proved for Cartesian ovals will be equally true for all curves which have cusps at *I, J, IJ* not a cuspidal tangent.

ON CERTAIN SYSTEMS OF CARTESIANS

13. The system of Cartesians given by

$$\rho^2 \pm 2A\rho - 2Bx + C^2 = 0,$$

where only $A$ varies, may be defined as a system having a common axial focus, and a common cuspo-focus, and such that the apices relative to the given focus lie on a circle having its center at the given focus.

By differentiating the general equation and eliminating $A$, we get

$$xdx + ydy + \frac{2Bx - C^2 - \rho^2}{2\rho^2}(xdx + ydy) - Bdx = 0.$$

Hence, putting $\frac{dx}{dy} = 0$, we get for the locus of the points of contact of the double tangents, and the axial points,

$$y(\rho^2 - 2Bx - C^2) = 0.$$

Putting $\frac{dy}{dx} = 0$, we get for the locus of the apices relative to the infinitely distant focus,

$$\rho^2 x - 2By^2 - C^2 x = x(\rho^2 - C^2) - 2By^2 = 0,$$

a circular cubic.

14. The system of Cartesians given by

$$\rho^2 \mp 2A\rho - 2Bx + C^2 = 0,$$

where only $C$ varies, may be defined as a system having a common axial focus, and a common cuspo-focus, and such that the points of contact of the double tangents lie on a circle having its center at the given axial focus.

We get from the general equation by differentiation,

$$xdx + ydy \mp A\frac{(xdx + ydy)}{\rho} - Bdx = 0;$$

whence, putting $\frac{dx}{dy} = 0$, we have for the points of contact of the double tangents, and the axial points, $(\rho \mp A)y = 0$.

For the apices relative to the infinitely distant focus, the locus is $(x - B)^2\rho^2 = A^2x^2$, the conchoid of Nicomedes.

In order to obtain the locus of the apices relative to the common focus, we have to put $\rho^2$ for $C^2$ in the equation of the sys-

tem. We then have $\rho^2 = Bx \pm A\rho$, the well known equation of a Limaçon.

15. The system of Cartesians given by

$$\rho^2 \mp 2A\rho - 2Bx + C^2 = 0,$$

where $B$ is constant, and $A^2 - C^2 = A$ constant, $= K^2$ say, may be defined as a system having a common focus, a common cuspo-focus, and the same double tangent. On differentiating and eliminating $A$ and $C$, between $\frac{dy}{dx} = 0$, the equation of the system, and the relation between $A$ and $C$, we obtain for the locus of the apices relative to the infinite focus,

$$2Bx^3 - B^2\rho^2 + K^2x^2 = 0.$$

Eliminating $A$ from the equation of the system, and putting $\rho^2$ for $C^2$, we get for the locus of the apices relative to the common focus,

$$2Bx\rho^2 - B^2x^2 + K^2\rho^2 = 0.$$

A remarkable relation exists between these two loci; for, if $x^2$ and $\rho^2$ be interchanged in the equation of either of them, the resultant is the equation of the other.

16. Two Cartesians having common one single focus, the cuspo-focus, and the double tangent being cut by concentric circles, center the given focus, the locus of the middle points of the intercepted arcs is a Cartesian having the same focus and cuspo-focus as the given Cartesians.

Cor.—When the two Cartesians are conjugate ovals, the locus becomes a circle, center at the cuspo-focus, and orthogonal to the circle of apices relative to the common focus. Its equation is

$$\rho^2 - 2Bx + C^2 = 0.$$

The theorem is at once seen to be true if reduction be first made to the auxiliary parabola, and then back again. It is capable of a wide extension, from which many interesting facts may be obtained.

17. A system of tri-confocal Cartesians is given by the equation

$$\rho^2 \mp 2A\rho - 2Bx + C^2 = 0, \qquad (1)$$

where $C$ is constant, and $A$ and $B$ vary in such a manner that

$$\frac{C^2 + B^2 - A^2}{B} = K, \qquad (2)$$

a constant.

The apices relative to the common focus pole lie on the circle $\rho=C$.

The distance, as we have seen, from the focus pole to the points of tangency of the double tangent of any oval is $A$; if, therefore, we put $A=\rho$ in (1) and (2), and eliminate $B$, we get the equation of the locus of the points of tangency of the double tangents, viz.:

$$\rho^2-4x^2+2Kx-C^2=0,$$

or, changing to Cartesian coordinates,

$$3x^2-y^2-2Kx+C^2=0.$$

Putting $\frac{dy}{dx}=0$ in the derivative of equation (1) we have

$$x\mp\frac{Ax}{\rho}-B=0, \quad or \quad \mp A=\frac{B-x}{x}\rho. \tag{3}$$

The general equation of the system gives us

$$\mp A=\frac{2Bx-\rho^2-C^2}{2\rho} \tag{4}$$

Equating these values of $A$ we have

$$2B\rho^2-2x\rho^2=2Bx^2-C^2x-\rho^2x;$$

whence,

$$B=\frac{x(\rho^2-C^2)}{2y^2} \tag{5}$$

Eliminating $A$ and $B$ between (2), (3), and (5) we have, after considerable reduction, for the locus of the apices relative to the infinitely distant focus,

$$3x^2-y^2-2Kx+C^2=0.$$

Hence follows the remarkable theorem—

The points of tangency of the double tangents and the apices relative to the infinite focus of a system of tri-confocal Cartesians lie on one and the same hyperbola. Furthermore, for a number of systems of tri-confocal Cartesians, all having one focus in common, but the other two foci any two points whatsoever on the common axis, the size and form of the hyperbola remain unchanged; merely its position is changed, the abscissa of its center being always one-third of the sum of the abscissae of the two axial foci not at the origin.

In fig. 3 two of the common axial foci are imaginary. The limiting Cartesian of the system is the arc $BC$ of the circle of apices. For when the auxiliary parabola reduces to the axis, the resulting Cartesian becomes the arc of a circle. In this case, the

cuspo-focus coincides with the focus pole, which is at the center of the circle. $B$, the point of intersection of the circle and the hyperbola, is one of the anti-foci of the axial foci not at the origin, it being real, as these foci themselves are imaginary. The curves repeat themselves symetrically on the other side of the axis.

In fig. 4 all three foci are real. In this case, the circle $C$ and the line joining the foci are the limiting forms of the Cartesians. When the foci are all real, the apices relative to the infinite focus and the points of tangency of the double tangents lie on different branches of the hyperbola. When two of the foci are imaginary, the two loci are on the same branch of the hyperbola, which now is the conjugate to the previous hyperbola.

Similarly, we have that

$$\rho^2 \mp 2A\rho - 2Bx + C^2 = 0,$$

where $C$ is constant, and

$$\frac{C^2 + B^2 - A^2}{-B} = K,$$

represents a tri-confocal system of Cartesians having the same foci as the preceding system. These two systems are, therefore, subsystems of one and the same system of Cartesians. Considering the manner of their derivation from the auxiliary parabolas, we see that the curves of the same subsystem do not intersect. Further, by means of these parabolas, it is easy to show that all the curves of one subsystem cut all the curves of the other subsystem at right angles. The loci of the apices relative to the infinitely distant focus and of the points of tangency of the double tangents are the same hyperbola as that obtained for the first subsystem.

Fig. 5 shows a complete system of tri-confocal Cartesians, two of the common foci of which are imaginary. In these figures, $m$ is the mean of the axial foci not at the origin, and $K_1$ is the cuspo-focus of the curve $(i)$.

18. It is interesting to note that if a system of Cartesians have in common any three single finite foci, which do not all lie on two of the focal tangents, they have in common all of their single foci. If, in addition, they have the same cuspo-focus, they either coincide or form a system of concentric circles.

19. The equation of a Cartesian can be expressed in the form.

$$(x^2+y^2-A^2)^2=4k(x-l). \tag{1}$$

Comparing this form of the equation with the form

$$(\rho^2-2Bx+C^2)^2=4A^2\rho^2, \tag{2}$$

We see that—

(1) If $l$ is constant, (1) represents a system of Cartesians which have a common focus, a common cuspo-focus, and such that the points of contact of the double tangents lie on a circle, center the cuspo-focus.

The locus of the apices relative to the infinite focus is the circular quartic.

$$(x^2-2Bx+B^2)\rho^2=(2Bx+k^2)x^2,$$

The locus of the apices relative to the common focus is

$$\rho^4-(4Bx+k^2)\rho^2+2B^2x^2=0,$$

a bicircular quartic having its real foci collinear. In these equations $B$ represents the distance from the common single focus to the cuspo-focus.

(2) If $a$ and $l$ both vary (1) represents a system of systems of Cartesians having a common single focus, a common cuspo-focus, and such that the apices relative to the common focus lie on concentric circles, center the origin.

All the systems of Cartesians obtained by variations in $a$ alone, or in both $a$ and $k$, have the same Jacobian, namely the line $y=0$, i. e., the common axis of the systems.

The systems obtained by variations in $k$ and $l$ have no Jacobian, as all the Cartesians belonging to these systems have 16 points in common.

20. Writing the equation of a Cartesian in the form

$$\rho^2\mp 2A\rho-2Bx+C^2=0,$$

or its identical form

$$(x^2+y^2-2Bx+C^2)^2=4A^2(x^2+y^2),$$

we find that the Jacobian of three Cartesians is given by the equation,

$$\begin{vmatrix} x(x^2+y^2)-B_1(3x^2+y^2)+(C_1^2+2B_1^2-2A_1^2)x-B_1C_1^2, \\ x(x^2+y^2)-B_2(3x^2+y^2)+(C_2^2+2B_2^2-2A_2^2)x-B_2C_2^2, \\ x(x^2+y^2)-B_3(3x^2+y^2)+(C_3^2+2B_3^2-2A_3^2)x-B_3C_3^2, \end{vmatrix}$$

$$\begin{vmatrix} y(x^2+y^2)+(C_1^2-2B_1x-2A_1^2)y, \\ y(x^2+y^2)+(C_2^2-2B_2x-2A_2^2)y, \\ y(x^2+y^2)+(C_3^2-2B_3x-2A_3^2)y, \end{vmatrix}$$

$$\begin{vmatrix} (C_1^2-B_1x-2A_1^2)(x^2+y^2)-2B_1^2x^2-3B_1C_1^2x+C_1^4 \\ (C_2^2-B_2x-2A_2^2)(x^2+y^2)-2B_2^2x^2-3B_2C_2^2x+C_2^4 \\ (C_3^2-B_3x-2A_3^2)(x^2+y^2)-2B_3^2x^2-3B_3C_3^2x+C_3^4 \end{vmatrix} =0$$

From this follows—

(1) When $A$ alone is variable. For a system of Cartesians having a common focus, a common cuspo-focus, and such that the apices relative to the common focus lie on a circle, center the origin, the Jacobian vanishes identically.

(2) When $B$ alone is variable. For a system of Cartesians having a common focus, and such that the apices relative to the common focus lie on a circle, and the points of tangency of the double tangents lie on another circle, both center the origin, the Jacobian vanishes identically.

(3) When $C$ alone is variable. For a system of Cartesians having in common one single focus and the cuspo-focus, and such that the points of tangency of the double tangents lie on a circle, center the origin, the Jacobian is the axis $y=0$.

(4) When $B$ is constant, and $A$, $C$ vary so that $A^2-C^2=k^2$, a constant, we have: for a system of Cartesians having in common a single focus and the cuspo-focus, and the double tangent, the Jacobian consists of the axis and a circle, namely,

$$y=0, \quad x^2+y^2-2Bx-k^2=0.$$

(5) When $B$ is constant, and $A$, $C$ vary so that $2A^2-C^2=k^2$, we have: for a system of Cartesians having in common a single focus and the cuspo-focus, and such that the points of contact of the double tangents lie on a circle, center the cuspo-focus, the Jacobian consists of the axis, and locus of the points of contact of the double tangents, namely,

$$y=0, \quad x^2+y^2-2Bx+k^2=0.$$

(6) When $C$ is constant, and $A$, $B$ vary so that

$$\frac{C^2+B^2-A^2}{B}=k,$$

For a system of tri-confocal Cartesians, the Jacobian consists of the axis, the locus of apices relative to the focus pole, and two orthogonal circles, centers the other two foci, namely,

$$y=0, \quad x^2+y^2-C^2=0,$$
$$x^2+y^2-(k+\sqrt{k^2-4C^2})x+C^2=0,$$
$$x^2+y^2-(k-\sqrt{k^2-4C^2})x+C^2=0.$$

(7) When $C$ is constant, and $A$, $B$ vary so that $A\pm B=k$.

[1] For a system of Cartesians having a common focus, and such that the apices relative to the common focus lie on a circle, and the vertices relative to the anti-foci of the axial foci not at the origin lie on another circle, both center the origin, the Jacobian consists of the axis, the circle of apices, and a double circle orthogonal to this last circle, namely,

$$y=0, \quad x^2+y^2-C^2=0,$$
$$(x^2+y^2\mp kx+C^2)^2=0.$$

21. The Hessian of a Cartesian given by equation (1) § 20, is $a^2(x^2+y^2)^3+6kx(x^2+y^2)^2-3(a^4+4kl)(x^2+y^2)^2-4ka^2x(x^2+y^2)+(3a^6+16kla^2)(x^2+y^2)+3k^2(3y^2+x^2)-2ka^4x-3k^2a^2-4kla^4-a^8=0$, a tricircular sextic with cusps at infinity and the same cuspidal tangents as the Cartesian. It follows that the two curves have 16 points in common at the cusps, and the remaining 8 points of intersection are the 8 points of inflexion of the Cartesian.

[1] This system is best studied by means of the auxiliary circle. See *Proc. London Math. Soc.*, III., 115.

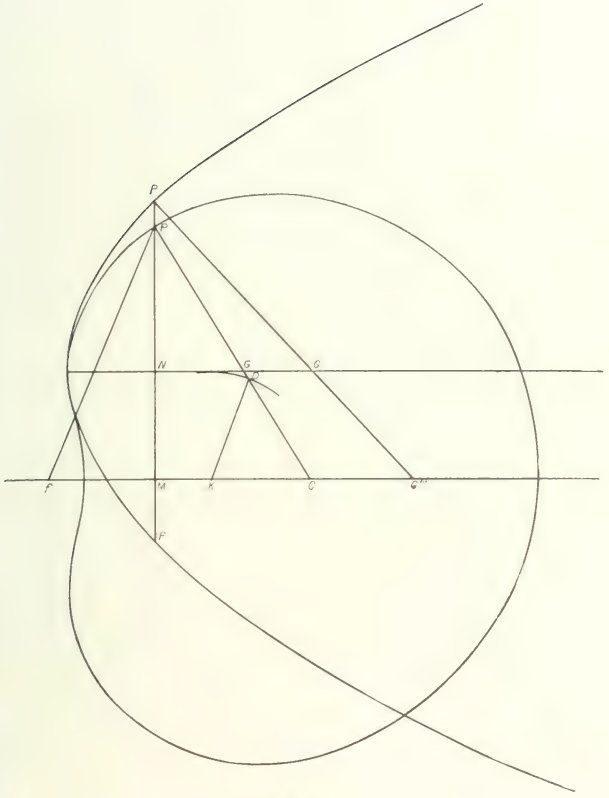


Fig. I

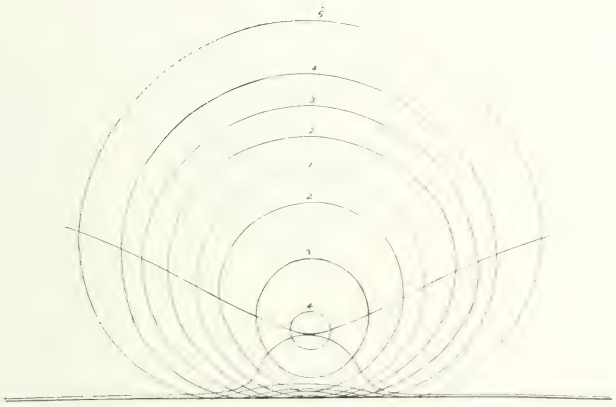

Fig. II.

$2Ax^{2} - B^{2}\rho^{2} - K^{2}x^{2} = 0.$

The equation of the locus of the apices relative to the infinite focus.

$2Ax\rho^{2} - B^{2}x^{2} - K^{2}\rho^{2} = 0.$

The locus of the apices relative to the common focus.

1 is a limiting case, and is a circle, center at the cuspo-focus.

5 has no conjugate oval.

The mean of the two axial foci not at the origin is the same for all curves of the system, and it is the point where the above-mentioned loci cross the axis.

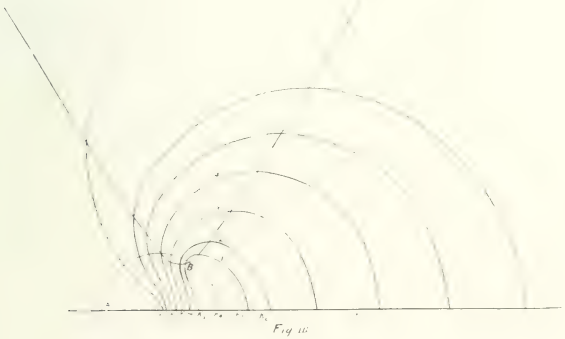

Fig. III.

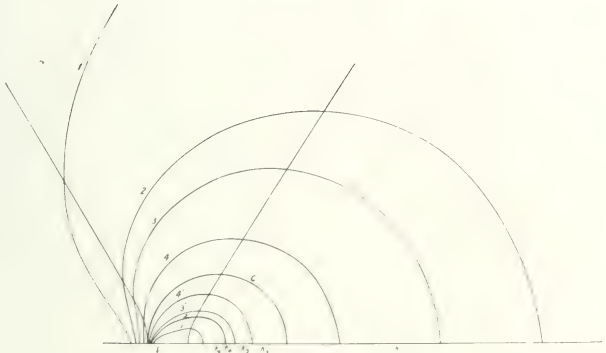

Fig IV

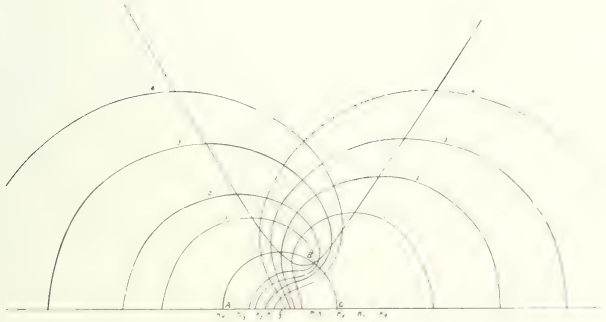

Fig V

# GEOLOGY OF LINCOLN AND ENVIRONS

BY C. A. FISHER, FELLOW IN GEOLOGY

During the summer of 1898, while in the employ of the State Geological Survey, under the direction of Mr. Erwin Hinckley Barbour, it occurred to the writer that a detailed survey of the geology of Lincoln and vicinity might give results of some scientific interest, and possibly of practical importance. Following out this idea for the past two years, personal visits and observations have been made from time to time at all points throughout the district. The information concerning the surface geology is the result of these observations, while the information regarding the underlying formation is compiled from records of deep well borings[1] and excavations. The relief map which accompanies this paper was compiled from a government topographical map made under the direction of Joseph H. Renshawe during the summer and autumn of 1894 and 1895.

Topography.—The region to which this paper relates consists of eighty-one square miles, lying a little north of the central part of Lancaster county, including Lincoln and its suburban towns. The topography in the region of the most typical drift-hills, which comprise the western half of this district, is very pronounced, while to the east the slopes are more gradual and the ravines less eroded, presenting, in the main, a moderately rolling surface. To the west the general level, covered by drift-hills, rises to an altitude of 1,500 ft., while the highest level to the east does not exceed 1,400 ft. The drift-hills also become very pronounced to the west, until a point is reached in the vicinity of Milford where the wide valley of the Big Blue river marks the boundary line between the hilly surface of the drift and the great loess-plain of Central Nebraska.

The broad valley of Salt creek passes from the southwest to the northeast through the central part of the area, serving as the principal drainage system of the entire district. The stream is

[1] *Sixth Biennial Report of Commissioner of Public Lands and Buildings to the Governor of the State of Nebraska*, December 1, 1888, pp. 57, 84.

small, scarcely exceeding 100 ft. at any point, and is characterized by perpendicular, alluvial banks. Just west of Lincoln, at a confluence of several tributaries of Salt creek, a large basin is formed which is known as the Great Salt basin. This low land, or a portion of it, has by artificial means been converted into the present Burlington lake. There are other smaller depressions which are called salt marshes. Two of these may be seen from the West Lincoln boulevard. They usually cover a very limited area, and connect with the nearest stream by a small outlet. During the rainy season they are filled with water, forming lakelets, while throughout the remainder, or dry portion, of the year a white precipitate, consisting of sodium chloride, calcium sulphate, and other salts, covers the salt flats. There are many other places in the valley of Salt creek where pronounced depressions in the surface indicate the previous existence of salt marshes, but the evidence is not conclusive.

Between the valley of Salt creek and the high drift-hills of the surrounding country there is a loess-plain varying in width from one-fourth to three-fourths mile, and rising to an altitude not exceeding 1,200 ft. It is upon this bench that the business part of Lincoln is built. The loess-plain has many points which project into the alluvial valley of Salt creek; some of these have suffered almost complete isolation by erosion. A typical example is the loess-island near 21st and Holdrege streets. Here we have a hill of loess including about twenty-five acres which is at present separated from the adjoining highlands by a small well marked ravine. There are other points in the valley which are being eroded in a similar manner at the present time; however, the work has not been carried to the extent that it is generally noticeable. (Fig. 1.)

Geology.—The superficial material concealing the greater part of the bed-rock in this region consists of drift, loess, and alluvium, with a few exposures of Dakota sandstone occurring at different levels. The drift occupies the hilly region, while the loess and alluvium are found along the valleys.

The underlying formation of eastern Nebraska dips strongly to the west. The beds found near the surface in the vicinity of Lincoln reach a depth of many hundred feet in western Nebraska and Wyoming, but rise again to the surface in the region of the

Rocky mountains. This elevated position of the formation in the West, which lifts to a high altitude the water-bearing beds, offers an explanation for a part of the artesian flow of eastern and northeastern Nebraska. (Fig. 2.)

The formation which immediately underlies the area under discussion is the Dakota Cretaceous. It is covered by a thick mantle of the Pleistocene, and rests upon the great Carboniferous group. The average thickness of the Dakota Cretaceous is about 240 ft., the base being marked by a thin layer of conglomerate. The beds do not differ materially from those found in other localities throughout the state, being composed of sand, sandstone, and an occasional bed of mottled clay.

The Carboniferous, consisting of alternating layers of limestone and blue shale, with occasional beds of sandstone, reaches a thickness of 830 ft. The limestone varies from a fine, compact, evenly bedded limestone to a calcareous shale, the latter of which is often highly stained with oxide of iron, and contains calcareous nodules. In fact, every gradation between limestone and shale is shown. The most common fossils are represented by the following genera: Productus, Athyris, Spirifer, Chonetes, Fusulina, Meekella. There is but one coal bed, that being found at a depth of 942 ft. It is an inferior quality of soft or bituminous coal. The impression of vegetation is indistinctly shown. Below this bed is the ancient soil which contains the marks of roots of plants. The age of the formation immediately underlying the Carboniferous, owing to a complete absence of fossiliferous evidence, is unknown. The doubtful beds, composed largely of heavy magnesian limestones, continue to a thickness of 715 ft., below which the lithological evidence becomes sufficient for fairly accurate determination. At this point we find a very fine blue limestone about 100 ft. thick, which, in many particulars, bears a close resemblance to the Trenton. Below this is a thin bed of sandstone, not unlike the St. Peter sandstone. The two remaining deposits, which, taken together, are about 250 ft. thick, resemble closely the Lower Magnesian and Potsdam, the latter lying immediately upon the Sioux quartzite. A complete list of the underlying formations with their respective thicknesses, from the surface down, may be summed up as follows: Dakota Cretaceous, 240 ft.; Carboniferous, 830 ft.; unknown age, 714 ft.;

Trenton limestone (?), 134 ft.; St. Peter (?) sandstone, 60 ft.; Lower Magnesian (?), 113 ft.; Potsdam sandstone (?), 71 ft.[1] (Figs. 3 and 4.)

The Dakota sandstone reaches the surface in the vicinity of Lincoln, while the Carboniferous makes its first appearance about twelve miles southeast of Lincoln, the dip of the Carboniferous being about northwest. To the west, in the region of the Rocky mountains, the Cretaceous is separated from the Carboniferous by several hundred feet of the Juratrias beds. These formations undoubtedly extend some distance into the state of Nebraska, but are entirely absent at Lincoln.

The heavy Pleistocene deposits of loess and drift which cover almost the entire upland surface in this area, together with the alluvial deposits of the valleys, make up the surface geology of the district.

Formations.—The Dakota sandstone is the only underlying formation which comes to the surface in this region. The Carboniferous lies about 250 ft. below the surface and does not outcrop for some distance east of Lincoln. There are several exposures of the Dakota sandstone in this area, and their occurrences are at different levels, indicating an irregular shore-line of the Carboniferous.

The Dakota outcrops of this region usually appear on the surface as fragmentary masses of rusty ferruginous sandstone with occasional evidence of concretionary structure. In texture this fragmentary material is very porous, resembling scoria in places, and contains fine grains of quartz and occasional bits of feldspar, and Sioux quartzite. A few feet lower the weathered fragmentary sandstone passes into that which is more solid, but at the best is very friable save in exceptional and local areas. Examples of strong cross-bedding are common. This is illustrated in various exposures and especially on the west bank of Salt creek about a mile south-east of the asylum. The characteristic Dakota leaves rarely occur in the exposures about Lincoln; however a few cases are recorded where the impressions of fragments of leaves and small pieces of bark have been found. The approximate location of the Dakota exposures is shown in fig. 9

[1] *Sixth Biennial Report of Commissioner of Public Lands and Buildings to the Governor of the State of Nebraska*, December 1, 1888, pp. 57, 84.

They are usually small, quite widely scattered, and due chiefly to removal of the glacial covering. The most extensive outcrops occur in the vicinity of the penitentiary and the Chicago, Rock Island & Pacific railroad crossing. Just southwest of the asylum, at the excavation made by the Lincoln Brick Co., can be seen the mottled clays of the Dakota underlying the drift and loess. Another similar excavation in a bank at the southern edge of West Lincoln exposes the highly colored Dakota clays overlying some iron-stained Dakota sand. The brown sandstone is exposed on Antelope creek just northeast of A street pumping station, at the "cave" in South Lincoln, and at the crossing of the Rock Island & Pacific railroad about a mile east of the penitentiary. There are other outcrops to the southwest. One which is very pronounced appears near the Jewish cemetery, and other smaller exposures occur along the valley of Haines's Branch. (Figs. 5 and 6.)

The Dakota sandstone is of interest not only from a scientific, but also from an economic standpoint, not that it furnishes so much building stone, but that it is in these beds that the people of Lincoln must look for water. In the eastern part of Nebraska this formation furnishes the great artesian water supply. In the region of Lincoln this formation does not furnish an artesian flow, but contains an inexhaustible quantity of water. The artesian water of Lincoln is obtained from the Carboniferous, the first flow being contained in a bed of light colored limestone 578 ft. from the surface, and a second in a very similar formation at a depth of 820 ft.

The salinity of the water in the Salt Creek basin was in early times considered important. During the territorial days there were quite extensive salt manufactories operated by the settlers, and a considerable amount of salt was produced at the basin through the process of solar evaporation. A deep test-well was sunk by the state at the south side of Burlington lake, the objective point being the Saline period of the Upper Silurian. This proved to be fruitless, and the project was abandoned after sinking the well to a depth of 2,463 ft. In this well the strongest brine as reported was found in a coarse gravel 195 ft. from the surface, which is near the base of the Cretaceous. This brine tested on an average 35° by the salimeter, and at times was ob-

served to reach nearly 40°.[1] The supply was almost inexhaustible. There were two smaller saline flows found in the undoubted Carboniferous, one at a depth of 600.5 ft., and the other at a depth of 828 ft. The brine of these two flows was not as strong, testing respectively 12° and 16°. Different theories have been advanced respecting the probable origin of the saline water of the Great Salt basin. Mr. B. P. Russell, geologist in charge of the test well, believed the Dakota beds to be the source of the saltness in the basin, while other equally good authorities that the Carboniferous contains the salt.[2] At present the latter theory is generally accepted.

The thick, irregular mantle of drift which belongs to the earlier Pleistocene deposits is the most widely distributed and probably the best represented formation of the area. It consists of a heterogeneous mass of boulders, clays, sands, and gravels. It constitutes high, irregular hills, traversed by deeply eroded, meandering ravines, and draws. The topography of the drift surface is usually sufficient to enable the geologist to determine the formation. In the western half of the area the glacial drift contains large boulders, while to the east the material is much finer, having less stony drift and fewer boulders. Frequently sand-pits are found in the drift; examples of this can be seen just north of West Lincoln. The exact location is shown in fig. 9. The quality of sand taken from these pits is suitable for nearly all varieties of mason work. The drift contains a small amount of water, although the supply is very limited, rarely exceeding the demands of a small household.

The loess of this region occupies a comparatively small space. It is not a part of the great loess deposit of central Nebraska, which abuts and overlaps the drift in the vicinity of the Big Blue river, but a lower-level phase which is found along the valleys of Salt creek and Little Nemaha river. This loess does not extend much above an altitude of 1,200 ft., in the region of Lincoln. In appearance it is a light buff-colored loam, containing small fresh-water and land shells, with now and then a small,

[1] *Sixth Biennial Report of Commissioner of Public Lands and Buildings to the Governor of the State of Nebraska*, December 1, 1888, pp. 57, 84.

[2] Darton, *Water Supply and Irrigation*, paper No. 12, "Underground Waters of Southeastern Nebraska," U. S. Geological Survey.

irregular-shaped concretion. It varies considerably in composition, in some places being more sandy than others. The loess around Lincoln occupies a position midway between the low alluvial deposit of Salt Creek valley and the high drift hills of the surrounding country. The most typical example of this formation may be seen at the Stockwell brick yards, about two miles south of the city; here we find the typical fossils and lime concretions well illustrated. The relative position of the loess with respect to the drift and Dakota is also clearly shown at this place. (Fig. 7.)

The alluvial deposit is quite extensive. It constitutes the valley of Salt creek, together with all its smaller tributaries. The average thickness is about forty feet, but this varies greatly with the location. The alluvium of the Salt Creek valley consists of a very fine loess-like material mixed with decayed vegetation and an occasional streak of fine gravel. Along the smaller tributaries of Salt creek the local origin of the material often renders it difficult to differentiate satisfactorily. (Figs. 8 and 9.)

Fig. 1. Relief map of Lincoln and vicinity, including [illegible] sq. mi. [illegible]

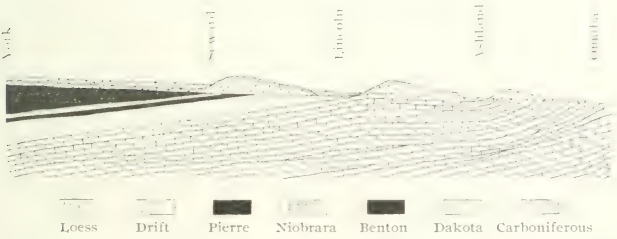


Fig. 2. Ideal section showing the approximate relation of underlying formation in vicinity of Lincoln. Portion of "Section from the Rocky mountains across Wyoming and Nebraska," U. S. G. S.

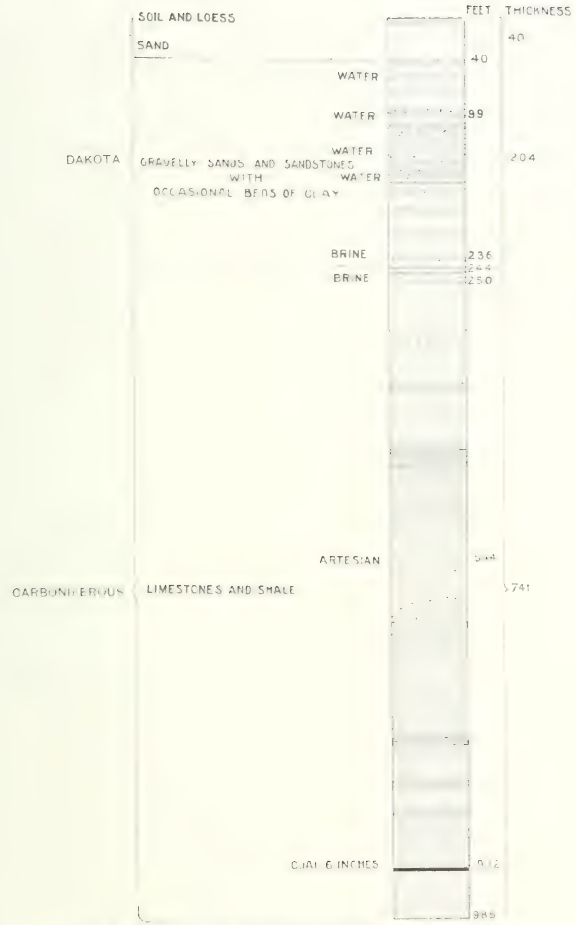


Fig. 3. Section of salt well in Government Square, Lincoln, Neb.

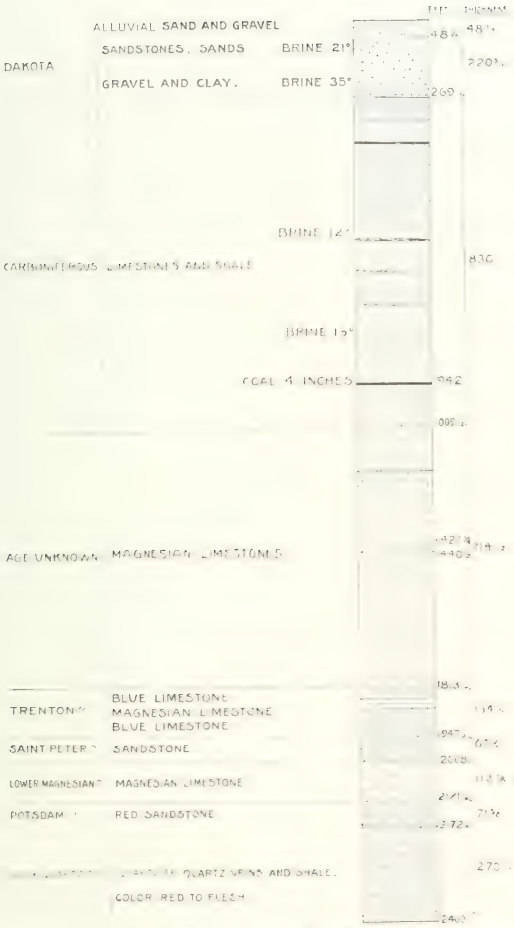


Fig. 1. Section of test well 1 mile west of Lawrence, Kans. Drawn from sketch and data furnished by E. P. Russell, geologist in charge of well.

Fig. 5. Ideal section showing the loess capping a coal sand which is similar to the Dakota. Taken from a street cut on 9th and M streets, Lincoln, Neb.

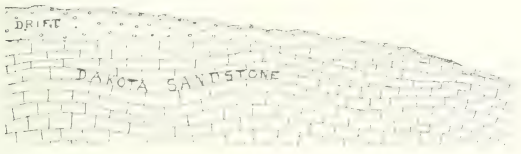


Fig. 6. Dakota sandstone underlying the glacial drift, showing irregular bedding.

Fig. 7. Ideal section of clay-pit southwest of Insane Asylum near Lincoln, Neb., showing the relative position of the formations.

Fig. 8. Ideal section across Salt Creek valley, showing the approximate relation of the surface formations.

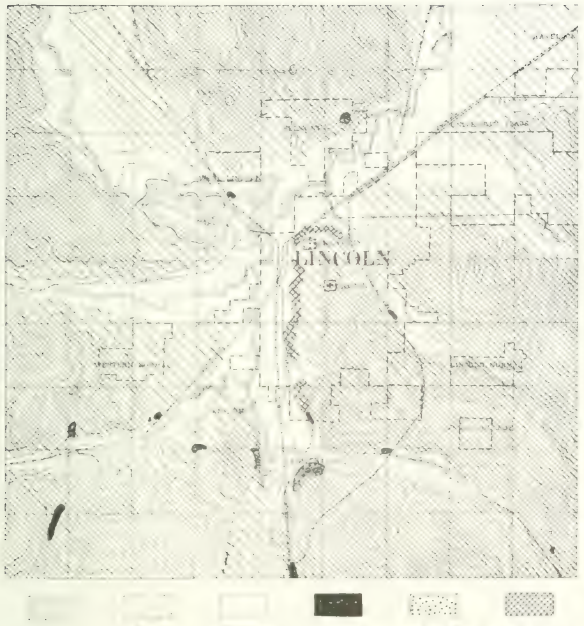


Fig. 9.—Geological map of Lincoln and environs.

# RAILROAD LEGISLATION IN NEBRASKA

BY R. S. BAKER, A.M.

Railroad building and railroad regulation in this country pass through three distinct stages of development. Each one of these stages covers about an equal period of time and is characterized by distinct policies. The first period was that of construction, in which there was no legislative interference, beginning with the year 1830 and closing with the projection of the Pacific railroad in 1860. The second period was one of bitter competition and the enactment of general statutes, merging from the former period and reaching fullest development in 1873. Third, in natural sequence, was a period of combination and active state interference or efforts to control, extending from 1873 to the present day. [1]

The same stages characterize the development of railroads and the evolution of railroad legislation in Nebraska, except that the transition was made in shorter periods of time. These stages in Nebraska are:

(*a*) Period of construction and public cooperation, in which there was freedom from legislative interference, 1855–75.

(*b*) Period of competition and statutory enactments, 1875–87.

(*c*) Period of combination and state interference, 1887–1900.

(*a*) FIRST PERIOD.—In the West, the building of railroads preceded the economic and material development of the different states. It is a fact well known to all who are acquainted with the general economic development of the United States that from the time of the acquisition of the northwest territory, and especially from the time of the purchase of Louisiana, plans were suggested both by private parties and public officials for giving this great territory commercial connection with the Atlantic seaboard.[2] The states manifested great activity in matters of

[1] Hadley, C. F. Adams, and Larrabee make similar divisions, but they cover different periods of time.

[2] Message of President Buchanan to Congress, December, 1856.

internal improvement, and sought to stimulate private enterprise to keep pace with public expectations.

Nebraska was only one of several western states which manifested unbounded enthusiasm in early railroad adventures and pronounced all restraining legislation as harmful and injudicious. But, happily, the state in its policy of internal improvement did not, in its corporate capacity, enter into railroad enterprises and commit the blunder of the older states—New York, Pennsylvania, Maryland, Ohio, Illinois, Michigan, and others.[1] A bit of paternalism in matters of internal improvements is disclosed in the action of the above states in sending memorials to Congress asking the general government to assume the payment of debts aggregating $200,000,000.[2] The collected data show that by 1840 the collapse of the state internal improvement enterprises, the vicious currency system, and the economic condition of the country stood out as a vivid lesson to the newer states, and served as a nightmare to all state activity in industrial enterprises.

By 1860 the population and wealth in Nebraska were increasing very fast. Immigration had trebled the population in the three years ending with 1860, until it aggregated 28,941. The true valuation of the real and personal property had increased to $69,277,483. The people began to feel a deep interest in developing better facilities than wagon transportation, in order to avail themselves of the natural advantages by which they were surrounded. They wished to open a market for the surplus products of their labor and industry in order to secure the development of their agricultural resources. The messages from the governors to the general assembly during the whole of the first period[3] reflect the people's desire for railroad building. Congress was memorialized for large land grants; the state donated lands and gave the counties, municipalities, and precincts power to subscribe bonds and other forms of aid. To make the railroad projectors feel positive of public cooperation, the legislature extended to them the marvelous benefits of special legislation.

The enthusiasm for railroads is revealed in a joint resolution and memorial of the general assembly, approved March 14,

[1] *Hunt's Merchant Mag.*, XVII.–XXV., *Gen. Stat. of Md.*

[2] *Com. Repts.*, 296, 32d Cong., 3d Ses., pp. 13–46 and 459–461.

[3] See messages of the governors, *House Jour.*, 1855–1876.

1855, asking a right of way and grant of land for the Platte Valley & Pacific Railroad Co.[1] The wisdom of granting each alternate section of land within twenty miles on either side of the road to aid construction was elaborately argued. The memorialists urged similar grants to the local roads—Missouri River & Platte Valley Co., Nebraska Central, Southern Nebraska, and the Yankton and Columbus railroads.[2]

The Kansas-Nebraska law in 1854 vested all legislative powers conferred by it in the governor and legislative assembly of the territory.[3] This, according to legal construction, included power to grant charters of incorporation to railroads and local communities. Until the adoption of the constitution of 1866, the territorial legislature followed the pernicious system of granting special charters to all railroad projectors.[4] These charters were dissimilar in character and could be amended, modified, or consolidated from year to year and new ones added to the list with changed provisions and requirements. Corporations were organized with sinister and sincere motives to take advantage of the liberal policy of the state.

No railroad charter was granted until the regular session of the first general assembly of the territory of Nebraska, 1855. This session granted two special charters, approved March 1 and 2, 1855, incorporating the Platte Valley & Pacific Railroad Co. and the Missouri River & Platte Valley Railroad Co.[5] From this time until 1867 the journals of both houses of the territorial legislature show that a large portion of the bills dealt with the granting of special charters for railroads, towns, etc. This method of special legislation is a peculiarity of the western states in their earlier history.

The first charters were simple in character.[6] They delegated to the companies the power of making, adopting, and being governed by such regulations and rules as their interests required, not incompatible with laws of the United States and the territory. Different companies could connect and consolidate their stock,

[1] *Laws of Neb.*, 1855–57, p. 350.
[2] The grants were in the following years: 1855, 1857, 1861, 1869.
[3] *Jour. of Ter. Counc.*, 1855, p. 10, also *Con. Rec.*, 1854.
[4] *Complete Ses. Laws*, 1855–75, p. 350.
[5] *Laws of Neb.*, 1855–57, p. 352.
[6] *Laws of Neb.*, 1855, p. 352.

provided they did not go so far as to assert the power and privileges of banking. The right of eminent domain was guaranteed. A railroad corporation could enter upon and take possession of all such lands as might be necessary to its construction and maintenance. This could be done either by purchase or condemnation. The capital stock of the road as provided in the first charter was $5,000,000, to be divided into shares of $100 each. The government and directors were invested in persons named in the act of incorporation. A majority of the incorporators could open subscription books for the stock of the company, and when 5 per cent was paid upon each share, until the total number of shares aggregated 2,000, an organization could be perfected. The company when organized, which was after paying only 5 per cent upon its nominal capital, could issue certificates of stock, borrow money not exceeding the capital stock, and, for the purpose of obtaining money with which to build or equip the road, it could issue interest-bearing bonds payable at stated times. To give them other benefits, the charter exempted the property of the corporation from taxation, unless the net proceeds exceeded 10 per cent per annum.[1]

This is only a sample of the many charters granted by Nebraska in its eagerness to foster railroad building. Those who pointed out the evils of such special legislation were looked upon as Cassandrian prophets, and their objections scarcely worthy of consideration.[2] A negative decision as to any charter for railroad building had no finality. The bill would be repeatedly introduced into the legislature until its passage became a fact. Any number of persons, ranging from one to fifteen or more, were allowed to start the construction of a railroad, provided they could form a company and pay in 5 per cent of the nominal capital.[3] The speculative spirit assured the sale of the stocks and a possibility of large fortunes being realized by those who could successfully sell out the public and manipulate the stock market. The stock exchanges were the theater of their action. Every conceivable

[1] Compare charters of Platte V. & Pac. R. R. Co. with charters of Cent. Pac. R. Co. and Neb. Cent. Ry. Co., *Laws of Neb.*, 1857, pp. 221–223.

[2] *Neb. House Jour.*, 1857, index.

[3] See charters of Mo. R. & Platte V. Ry. Co., 1850; Neb. Cent. Ry. Co., 1857; Cent. Pac. Ry. Co., 1857; Yank. & Col. Ry., 1869.

design was broached to make the public believe the road was a paying investment, and that it was receiving liberal returns for the government's liberal policy.

After perfecting the articles of incorporation it was not uncommon for members of the company to form a construction company within or under the supervision of the general company, to whom would be delegated the building of the road.[1] The construction company, although directors of the original company, would issue to themselves interest-bearing bonds to pay the cost of construction. Upon completion of the road they would borrow money to pay interest upon the bonds and also dividends upon the stock. Moreover, when these speculators and stockholders desired to sell their stocks and bonds, they would force up the market value and sell them on the stock exchange at a large premium, leaving almost a bankrupt road in the possession of the stockholders.[2] Evidently the exchange of stocks and bonds upon an abnormal market with such fruitful returns would be an incentive to speculation and to railroad investment in the West. Psychological forces as manifested in the speculative spirit on the stock exchanges and in the liberal legislative acts of the government, both state and national, gave rise to an intense fever for railroad building.

In the first legislative session there was no apprehension of railroads being overbuilt.[3] Subscription to railroad stock took the form of popular movement. As the number of miles increased in the state, the demands for more local lines became intensified. A study of the distinguishing features of the special charters granted during this period would be invaluable in tracing the internal history and growth of corporations.

The organic laws of the state formulated in 1856 contained only general provisions respecting railroads.[4] These were indifferently enforced. No restrictions were made other than requiring a certain formality to be followed in applying for charters. Nothing was said as to the number of persons or the

[1] *Affairs of the U. P. Ry.*, p. 852.

[2] *Affairs of U. P. Ry. Com.*, VIII., index, also History of N. B. H. Ry. Co., *Rep. Board of Trans.*, II., 143.

[3] *House and Senate Jour.*, 1855–57, Com. on Rys.

[4] *Laws of Neb.*, 1855–57, p. 37, "Corporations."

amount of capital requisite to perfect the corporation. This was left to the discretion of railroad projectors. The framers of these laws apparently considered them public favorites working for the public good. Whatever protection and favoritism a company demanded would be carefully provided in the special charter.[1] Subsequent action of the legislature reveals that the people were conscious of this extremely liberal policy, and hence sought to counteract it in asking restriction upon extensive grants of public domain in the aid of private enterprises.

In a memorial to Congress, 1857,[2] the legislature characterized the grant of two hundred million acres of public lands to railroad corporations as "signalizing the birth of a monster land monopoly whose unrelenting grasp would hold from the industrial population the settlement and cultivation of a valuable part of the territorial domain." Although the memorial alleged that excessive grants like those to the Pacific road and certain local lines would endanger the industrial development of the state, yet it favored limited donations sufficiently large to stimulate industrial enterprises.[3] The grant of the Pacific road was closed from settlement, and until the company applied for letters patent, they were exempt from taxation. The people in a memorial to Congress approved in 1872[4] represented that the depression in business and the low prices of all farm products throughout Nebraska and the difficulty of obtaining money necessitated some relief to the taxpayers.[5] This relief, said the memorial, should come through a congressional act compelling railroad corporations to share the burden of the taxes incurred for government purposes. Thus necessity compelled a reaction against former liberality.

The Burlington & Missouri River railroad held for several years large tracts of public lands, when the road had no existence except upon paper.[6] The road was finally located to run west from Plattsmouth to the hundredth meridian. The dilatory

[1] *Neb. Stat.*, 3d Ses., p. 221. Compare charter Neb. Cent. R. R. Co. with the others cited.

[2] *Laws of Neb.*, 1855–57, p. 288.

[3] Memorial to Cong., *Laws of Neb.*, 1861, index.

[4] *Stat. of Neb.*, 1867–73, 8th Ses., p. 27, adjourned session.

[5] Result of forces at work precipitating the monetary panic of 1873.

[6] *House Jour.*, 1867, p. 19.

action of railroad projectors called forth the proposal from Governor Saunders in 1867,[1] "that the agricultural interests of the state would fare infinitely better if Congress would make an appropriation and pay in money the value of the lands instead of holding them from homesteaders."

By an act of Congress entitled "an act to appropriate the proceeds of public lands and to grant preemptions," approved September 14, 1841, there was granted to certain states, including each new state that might thereafter be admitted into the Union, five hundred thousand acres of land for purposes of internal improvement.[2] In 1854 Congress conveyed the fee simple title in the land thus granted to the states. In accordance therewith the legislature of Nebraska, by an act approved February 15, 1869, provided for the disposal of these lands to the various railroad companies within the state.[3] This law gave to each road two thousand acres of land with letters patent for every mile of road thereafter constructed. However, an express condition was made that each railroad company must complete ten consecutive miles of its road, with the approval of state authorities, before letters patent would be issued.

To insure a proper distribution of land among the various railroads, the law provided that no one company should be entitled to receive more than one hundred thousand acres.[4] The companies were compelled to sell these lands in tracts not larger than 150 acres within five years from the date of the letters patent, at a price not less than $1.25 per acre.[5] The Pacific railroad and like companies having grants from the general government enjoyed the privileges of the act for the first twenty-five miles, thus limiting their grant to fifty thousand acres.

This act marks the first grant of aid made indirectly by the state for railroad construction. The primary object, said Governor Richardson, was to encourage the building of local and branch lines through the fertile and productive counties.[6]

[1] Governor's Message, *House Jour.*, 1867, p. 22.

[2] *Cong. Rec.*, 1841, Sept. 14.

[3] *Stat. of Neb.*, 1867–73. *Gen. Laws*, p. 153.

[4] Act of 1869 to dispose of Public Lands granted to Nebraska for Internal Improvements.

[5] Ibid., sec. 4.

[6] *Stat. of Neb.*, 1875–79, 13th Ses., p. 166, Land grant to Pacific railroad.

In this period, as before stated, the people of Nebraska were awakened and quickened in every avenue of industrial life. The great question to be answered was how to secure funds and arouse private enterprise to the needs of the times in local and through railroad building. The liberal policy of national and state land grants was not sufficient. But the experiences of other states, which have been already considered, demonstrated to the people of Nebraska that the state should not attempt the construction of roads wholly as a state enterprise.

Notwithstanding this, private enterprise must be assisted. It did not keep pace with public expectation. Moreover, railroad projectors, inspired with the speculative spirit, actually withheld the investment of capital until greater inducements were offered. The state in 1870 had a population of 122,993[1] possessing a taxable wealth of $69,277,483.[2] In a state of such resources companies could not be formed for the construction of railroads demanding large amounts of capital. As it was regarded bad policy for the state to engage in the work of actual construction, or to aid in the construction of the roads by becoming a stockholder, and as private capital did not awake to the public needs, the only course open by which the people of Nebraska could get the desired needs of transportation was that of combining private capital with public credit, the latter of which was extended in the form of county, precinct, and municipal bonds.

As a result, therefore, of the increasing commercial activity of the time and in accordance with the enterprising public opinion of the state, the legislature passed an act February 15, 1869,[3] to enable counties, cities, and precincts to borrow money on their bonds, or to issue bonds to aid in the construction or completion of works of internal improvement in the state. Capital had to be imported, and this, it was thought, could best be done by using the public credit in the above manner. This decision made in the beginning of railroad legislation kept the state in its corporate capacity from becoming involved in the management of the roads in any way, and left to each county and community the

[1] *Rep. of Sec. of State*, 1870, or *U. S. Census Rep.*, 1870.
[2] *Auditor's Rep.*, 1870, or *U. S. Census Rep.*, 1870.
[3] *Complete Ses. Laws of Neb.*, 1866–77, p. 439.

option of bonding and taxing itself for the benefit of local and public works.

The main features of the act for internal improvements were: first, that any county, city, or precinct could issue bonds to aid in the construction of a railroad to an amount to be determined by the county commissioners or city council, not exceeding 10 per cent of the assessed valuation of all the taxable property.[1] Second, the question of issuing bonds must be submitted to popular vote, majority deciding, accompanied by a provision to levy an exclusive tax for the payment of the principal and interest.[2] Third, the holders of the bonds were paid from a special tax upon all taxable property.

This act was amended March 3, 1870,[3] making it compulsory on the tax payers to levy and collect an additional tax to pay off the bonds when they became due. It was also amended February 17, 1875,[4] making a two-thirds vote necessary for the issuance of such bonds. Although the original act was slightly changed after 1875, yet the essential provisions above stated remain the same until this day.

Prior to this general law, the legislature enacted what was called, "private, local, and temporary laws" of a special nature, under which it legalized the county and precinct issue of bonds for the aid of railroad construction. Otoe, Richardson, Dakota, and Saunders are a few of the counties that voted, with little dissension, bonds to help construct the roads through their respective counties. Their action was legalized by the legislature in the form of special laws and with the consciousness of fulfilling a sound public policy.

These various laws when taken in connection with the new constitution of 1875 reflect the public consciousness of this period upon the development of the railroad industry. What relation does the development of the railroad bear to the economic development of the state? How far are Adams, Dillion, and other political economic writers justified in asserting that the growth

[1] See secs. 1 and 2, Act to aid internal improvements.
[2] See secs. 2 and 4, Act to aid internal improvements.
[3] See secs. 5 and 8, Act to aid internal improvements.
[4] *Stat. of Neb.*, 1867–73, 6th Ses., p. 15.

of the Upper Mississippi basin and the West are due largely to railroad facilities?

In those states supplied with natural waterways the railroad was of little utility. The products were conveyed with greater economy and below the cost of operating railroads. But the geographical situation of Iowa, Nebraska, and the Dakotas placed a high utility upon railroad transportation. Consequently the pioneer shipper paid dearly for transportation. Before the railroad, he relied on wagons.[1] After the railroad he fared for the first few years but little better, as the charges for passenger and freight traffic were determined by the cost of wagon transportation. The wagoners were the competitors of the railroads, and until the state became more populated and the railroads more numerous they constituted the only effective regulator of railroad rates.[2]

As the roads multiplied and industries increased, transportation abuses continued. In 1881 there was introduced into the legislature the first act "to fix a maximum standard of freight charges on railroads and to prevent unjust descriminations therein."[3] This law was of little utility, first, because of inadequate information as to the practices of the roads; second, because of the indifference as to its enforcement; third, because of its extremely general character.

The main features of the act were, first, that every railroad corporation should provide reasonable and equal rates for the transportation of property; second, no railroad company should collect a higher rate for service than was charged for like service in November, 1880, as shown by the published schedules of the company; third, no railroad should grant any secret rates, rebates, or drawbacks, or discriminate against persons.

This law, although subsequently repealed in 1887,[4] provided that the roads should give equal facilities to all shippers, and contains the germ of legislative restrictions. However, there was no effort to secure enforcement or radically change the

[1] *Rept. of Board of Immigration*, 1870.
[2] *Evidence Maximum Rate Case*, p. 194.
[3] *Laws of Neb.*, 1881, p. 310.
[4] *Laws of Neb.*, 1887, p. 541.

prevailing practice of railroad management.[1] The other railroad acts of the legislature of 1881 provided for annual reports to be made to the state auditor, and set forth the necessary requirements for consolidation.[2]

The enactment of the interstate commerce law in 1887 was the beginning of a new era in state and national railroad legislation.[3] The passage of this law was instrumental in causing a number of states to enact laws containing the substance, if not the exact words, of the interstate commerce act. It gave an impulse to establishing state commissions. Nebraska, Missouri, Iowa, Connecticut, Oregon, and the two Dakotas made important and even radical changes in their commission laws, either in the same or in the following year.[4] The legislative act repealing the commission law of 1885 and replacing it with an act "to regulate railroads, prevent unjust discriminations, provide for board of transportation and define its duties,"[5] represents the beginning of real anti-railroad legislation in Nebraska. The board of transportation stood in contrast to the commission of 1885, in that it was not limited to merely the function of supervision and recommendation. It was a type of those commissions that may be termed regulative in function and character. The power of regulation gave strength to the board and avoided the deficiencies of the law repealed. The findings of the board were made *prima facie* evidence of the facts found, and the schedule of rates which it formulated were declared to be *prima facie* reasonable.[6] The burden of proof was shifted upon the railroads to prove, in case it charged a rate in excess of the schedule established by the board, that the rate charged was reasonable. This method of procedure was opposite to the common law practice, and was a new departure in railroad legislation, and

[1] *Laws of Neb.*, 1881, p. 303, act authorizing sale of railroads; also act to amend sec. 114 of ch. 11 of Gen. Stat., 1873, *Laws of Neb.*, 1881, p. 305.

[2] *Laws of Neb.*, 1881, p. 303, act authorizing sale of railroads; also act to amend sec. 114 of ch. 11 of Gen. Stat., 1873, *Laws of Neb.*, 1881, p. 305.

[3] Interstate Commerce Bill passed Congress Jan., 1887, signed by Pres. Cleveland, Feb. 4, 1887.

[4] See statutes of respective states for 1887 and 1888.

[5] *Laws of Neb.*, 1887, pp. 541–561.

[6] *Laws of Neb.*, 1887, pp. 541–561.

primarily distinguishes the third period from those preceding in Nebraska legislation.

The constitution of 1875 declared the railroads to be public highways and subject to the rules and regulations prescribed by law. Public opinion as therein manifested had engendered bad feeling between railroad managers and the people, and what should be a question of inquiry had come to be a question of controversy. During the first two periods, the common law was inadequate to maintain equity and relative justice. The declaration of the interstate commerce law was accompanied by a more perfect readjustment of railroad legislation to actual conditions, and culminated in causing many of the states actively to interfere with free competition.

The following is a summary of the essential features of the law creating the board of transportation:[1] first, to provide reasonable and just charges for the transportation of passengers or property. Second, to prevent discrimination between persons and localities in the transportation of a like kind of traffic or in the performance of like service. Third, to make it obligatory upon the carrier to accord to every shipper and locality equal facilities for the interchange of traffic between their respective lines. Fourth, to allow carriers to charge less for longer than for shorter hauls, providing the board, after investigation, concludes such a step advisable. Fifth, to prevent agreement or combination of carriers for the pooling of freights or the division of the proceeds of different and competing roads. Sixth, to compel the keeping of schedules of rates and the changes made, either by advance or reduction, open to public inspection. Seventh, to provide that schedules of rates and contracts between roads for joint tariffs be filed with the board, which in turn should publish the same for the use of the public. Eighth, to provide that the board consist of the attorney general, secretary of state, auditor of public accounts, state treasurer, and commissioner of public lands and buildings, and three appointed secretaries. The secretaries should hear and decide upon all complaints made against the roads. Ninth, to inquire into the management of the business of railroad corporations and require the attendance and testimony of witnesses and the production of books, papers, tariffs,

[1] *Laws of Neb.*, 1887, pp. 541–561.

and documents relating to any matter under investigation. The aid of the courts may be invoked to accomplish this end. Tenth, to prosecute all violations of the statute in the courts. Eleventh, to inspect the condition of each road and its equipments and investigate all complaints. Twelfth, to make findings of the fact in the complaints; and the board is empowered to invoke the aid of the state courts to compel compliance with the orders. Thirteenth, to prescribe the form of reports which the roads were required to make to the board annually. Fourteenth, to empower the secretaries of the board to perform the duties prescribed by the law except that all final decisions should be made by the board itself.

The above law was hotly contested both in the house and in the senate. The credit of its enactment is due to no political party, but to those members who were opposed to monopoly and corporate power.[1] Since the constitution of 1875 made it mandatory upon the general assembly to enact certain laws for the control of railroads, the representatives of the agricultural counties fought vigorously for something more than mere nominal legislation. The measure as originally proposed in the house was defeated in the senate,[2] and the law is the result of a compromise, which barely succeeded in passing the latter house.[3] The desire for railroad legislation is seen in the fact that there were twenty-six bills introduced in the house and thirty-one bills introduced in the senate affecting railroads in some form or another. Out of this number, there was but one distinct bill in addition to the above which became a law.[4]

The board was instituted to administer the law under the authority of the legislature, which in turn, as before stated, found its authority in the constitution itself. Naturally, the railroads resisted every effort of the board to execute the new law, until the question of its constitutionality was determined by the supreme court.[5] When the supreme court affirmed the right of the board to fix rates, the railroads acquiesced unwillingly, and hence the

[1] Compare vote, *House Jour.*, 1887, p. 1098, and *Senate Jour.*, p. 1015.
[2] *Senate Jour.*, 1887, p. 1015.
[3] *Senate Jour.*, 1887, p. 1015.
[4] *Laws of Neb.*, 1887, p. 539.
[5] 25 Neb., 156.

weaknesses of the present law are becoming apparent as it grows older.

The maximum rate law of 1887, while a crude application of state control, was an incentive to demand more control and greater reduction of rates. The board of transportation in 1891, under the pressure of public opinion, made an investigation of local freight rates.[1] The result of the investigation was a general reduction on local rates of 33.5 per cent.[2] The roads acquiesced, in light of the fact that they had in 1887 fought determinedly a similar proposal. This conclusion of the board was arrived at by making computations upon the basis of what it would cost to duplicate the property at the time of investigation.

However, at this period of our economic development, perhaps it would have been an injustice to carriers to have enforced the minimum rate with minimum returns. The table[3] shows that in 1887 the mileage was 3,983, while the gross earnings upon total investment of $119,643,000 were $19,232,892, leaving the net earnings for the year's management at $7,476,664. The net earnings were only .062 per cent of the total investment. Although the remuneration appears to be reduced almost to a minimum, yet within the next three years, ending with 1890, the mileage had increased to 5,136.47, and the aggregate cost of the roads, according to the estimate of the board, was $154,094,100. The mileage had increased during the three years 1,148.47, while the net earnings decreased from $7,476,664 to $7,126,829.

[1] *Fifth An. Rep.*, 1891, index.

[2] *Fifth An. Rep.*, 1891, index.

[3] Mileage of Nebraska railroads according to *Poor's Manual:*

| DEC. 31 | MILES | DEC. 31 | MILES | DEC. 31 | MILES |
|---|---|---|---|---|---|
| 1866 | 305 | 1878 | 1,344 | 1889 | 5,046 |
| 1867 | 473 | 1879 | 1,634 | 1890 | 5,136 |
| 1868 | 473 | 1880 | 1,953 | 1891 | 5,407 |
| 1869 | 473 | 1881 | 2,277 | 1892 | 5,511 |
| 1870 | 705 | 1882 | 2,498 | 1893 | 5,529 |
| 1871 | 943 | 1883 | 2,696 | 1894 | 5,585 |
| 1872 | 1,051 | 1884 | 2,794 | 1895 | 5,587 |
| 1873 | 1,107 | 1885 | 2,948 | 1896 | 5,583 |
| 1874 | 1,107 | 1886 | 3,615 | 1897 | 5,586 |
| 1875 | 1,127 | 1887 | 3,983 | 1898 | 5,542 |
| 1876 | 1,150 | 1888 | 4,905 | 1899 | 5,611 |
| 1877 | 1,286 | | | | |

Upon the estimate cost of duplication, the net earnings aggregated only .46 per cent of the total investment. The board's estimated cost of $30,000 per mile is considerably below what the road claims the actual costs to be; and, in view of the computations, to have asked a further reduction of local rates would have been asking commercial suicide. An explanation of the reduction of net earnings is found in the necessity of the roads extending their lines through territory economically undeveloped. The original plan of the investors had to be carried out, and consequently there was a sacrifice of immediate profit at the risk of future gain. Evidently railroad investments in the state were the result of farsighted financiering and of the expectation of compensating returns.

The problem of the relation between the par value of railroad capitalization and the just value of railroad property is one of extreme difficulty. It is quite questionable whether railroads are entitled to interest and dividend upon the original cost of their property without regard to how much the cost may have been enhanced by profligate expenditure or by misappropriation of funds.

The total capital stock invested in the railroads of Nebraska in 1885 was $66,292,832.63.[1] With a mileage of 2,948.37, this makes an actual investment of $22,213.08 per mile. A notable fact is that the aggregate funded and unfunded indebtedness of the roads for the same year amounted to $83,122,813.24 or $16,129,980.61 in excess of the capital stock.[2] The aggregate stock, funded and unfunded debt, was $149,415,645.80. The total cost of construction and equipment of the above mileage was $134,931,243.35, or an average of $45,212.30 per mile. It should be remembered that the Union Pacific reports a cost per mile double that of any other road, and hence the above average is not a fair index of the cost of each line per mile. The excess of stock and debt over cost of road and equipment aggregates $14,484,402.57. The gross earnings for the year amounted to $15,720,747.95, while the operating expenses aggregated $8,207,-304.18, leaving $7,513,443.77 as the actual net earnings. The net earnings for 1886 exceeded those of subsequent years with

[1] *Rep. Board of R. R. Com.*, 1886, p. 4.
[2] *Rep. Board of R. R. Com.*, 1886, p. 5.

the exception of 1890 and 1897. This is largely due to the fact that investments were being made to complete projected lines.

Upon passage of the maximum rate bill,[1] in 1893, all acts inconsistent with it were thereby repealed, which meant practically a nullification of several years of useless legislation. This law, under the provisions of the constitution, was to have gone into effect August 1, 1893. But in July, 1893, the C., B. & Q. R. R. Co. commenced an action in the circuit court of the United States against the board of transportation, enjoining the board from placing the schedule of rates in force. Later the stockholders of the various railroads[2] instituted suits against the board and against the various railroad companies seeking to prevent the enforcement of the law. Temporary injunctions were granted in each case, and in the meantime a voluminous amount of testimony was presented to the court covering every aspect of railroad management within the state.[3] For this reason, Nebraska, rather than other states, is in a better condition to arrive at practical conclusions upon the railroad question.

The act provided for a classification extending from A to Z inclusive and was known as the "Nebraska Classification."[4] The maximum rate varied with the class, whether first, second, third, fourth, or fifth class. The board of transportation was empowered to reduce the rates on any class of commodity in the schedule whenever it should seem just and reasonable. Furthermore, when any road showed that the schedule prescribed was unjust, they were exempt therefrom. But the rates were never to be raised above those charged by the roads in January, 1893.[5] The grave question involved the reasonableness of the maximum schedule of rates and the fairness of the classification. There can be no justice in that which works to the investors a practical destruction of their property invested. The property put into railroads is put there permanently, and that fact must be a determinant in establishing a criterion of a reasonable schedule of rates.

[1] *House Jour.*, 1893, p. 91; also *Laws of Neb.*, 1893, p. 164.

[2] *Eighth An. Rep. Board of Trans.*, p. 20, C. & N. W. R. R., U. P., C., B. & Q., M. P., and C., R. I. & P.

[3] Hearing of evidence at Omaha before circuit court, *Court Rec.*, p. 93.

[4] *Laws of Neb.*, 1893, p. 165.

[5] *Laws of Neb.*, p. 345.

The roads in making their rates, where there is no friction with the state, base their estimate on conditions and circumstances.[1] Take the item of coal to Lincoln. The rate on coal from Des Moines to Omaha, 125 miles, is $1 per ton. The charge for hauling it to Lincoln, 55 miles farther, is only fifteen cents more, or $1.15 per ton. This additional fifty-five miles evidently is rated at three-fourths of a cent per hundred miles.[2] This rate is made for the purpose of encouraging the building of manufacturing establishments in Lincoln. Similar rates were made by the roads on live stock to South Omaha, and the roads maintained that it is through their fostering care that there have been built up stock yards and packing houses which spend annually $35,000,000 for management of their business.[3] In making the rates favorable to South Omaha, it is impossible to say upon what basis they were made. But apparently from the evidence, the general freight agent considered the volume of business, the commercial necessities, and the competition of other roads.

The cost of constructing the first one hundred miles of the U. P. R. R. in Nebraska is a fair index of what must be considered in the framing of a maximum tariff schedule. The Dey line is the first location of the Union Pacific road west of Omaha.[4] Dey prepared, September, 1864, his first estimate for constructing a hundred miles of the road at $30,000 per mile.[5] In compliance with instructions received from the New York office of the company, he prepared a second estimate at $50,000 per mile.[6] Under directions from Durant, the estimate was increased from $30,000 to $50,000 per mile, and this was the estimate made in the Hoxie contract.[7] The result of the three contracts—the Hoxie, Ames, and Davis contracts—was as follows:[8]

[1] *Evidence Maximum Rate Case*, p. 95.
[2] *Evidence Maximum Rate Case*, pp. 95 and 96.
[3] *Evidence Maximum Rate Case*, p. 96.
[4] *Evidence Maximum Rate Case*, p. 476.
[5] *Evidence Maximum Rate Case*, p. 477.
[6] *Evidence Maximum Rate Case*, p. 477.
[7] *Evidence Maximum Rate Case*, p. 482.
[8] *Affairs of U. P. Ry. Co., House of Rep. Repts., 42d Cong., 3d Ses. Repts.*, No. 78.

| | | |
|---|---|---|
| A. | Cost to the railroad company— | |
| 1. | Hoxie contract | $12,974,416 24 |
| 2. | Ames contract | 51,140,102 94 |
| 3. | Davis contract | 23,431,768 10 |
| | Total | $93,546,287 28 |
| B. | Cost to contractors— | |
| 1. | Hoxie contract | $ 7,806,183 33 |
| 2. | Ames contract | 27,285,141 99 |
| 3. | Davis contract | 15,629,633 62 |
| | Total | $50,720,958 94 |

The difference between the cost to the railroad company and the cost to the contractors is $42,825,328.34. The latter sum is the amount which accrued to the contractors as profit upon the investment. The Hoxie contract which built a large share of the roads through Nebraska cost the company $12,974,416.24, while the subcontractors fulfilled the requirements with an expenditure of $7,806,183.33. Apparently the compensation, as far as these contracts were concerned, was remunerative.

The actual cost of construction under these three contracts was equivalent to the proceeds of the first mortgage bonds of the company and of the government bonds, as shown by the following table:

| | |
|---|---|
| First mortgage bonds issued | $27,213,000 00 |
| Sold at a discount of | 3,494,991 23 |
| Net proceeds | $23,718,008 77 |
| Government bonds issued | $27,236,512 00 |
| Sold at a discount of | 91,348 72 |
| Net proceeds | $27,145,163 28 |
| Aggregate net proceeds of both classes | $50,863,172 05 |
| Cost of whole road to contractors | 50,720,958 94 |
| Differences between proceeds of bonds and cost | $142,213 11 |

The actual profits realized from these contracts, after reducing the bonds issued to their cash value and charging the stock issued at thirty cents on the dollar, were $23,366,319.81.[1] The profits on the itemized contracts were as follows:

[1] *Affairs U. P. Ry. Com.*, p. 67, or *Ev. Max. R. Case*, p. 853.

| | |
|---|---|
| Ames and Davis contracts— | |
| Bonds (cash value) - - - - | $11,310,900 00 |
| $24,000,000 of stock at 30 - - - | 7,200,000 00 |
| Cash - - - - - - - - | 2,346,000 00 |
| Hoxie contract— | |
| $1,125,000 first mortgage bonds at 85 - - | 965,250 00 |
| $5,147,237.71 stock at 30 - - - | 1,544,169 81 |
| Total cash profit - - - - - | $23,366,319 81 |

The benefits arising from these contracts are immaterial compared with the effect that such a method of capitalization has on framing a reasonable system of rates. It is apparent from inspecting the tables that the mileage of the main line of the Union Pacific road in Nebraska was bonded and stocked so that the state shared in giving the profits accruing to the construction company and inside combinations. The fictitious capitalization aggregated $172,347,115 for the whole Pacific system. By reckoning upon the mileage basis, the amount of fictitious capital belonging to the road in Nebraska can be ascertained. The present capitalization and indebtedness of the road represents triple the cost of its duplication.[1] The maintenance of the present inflated capitalization would require extortionate rates of transportation. This railroad, more than any other, has caused the people of Nebraska to become distrustful of corporate management. Stock manipulation and speculative practices have been instrumental in inducing investigation and in establishing maximum rates.[2]

The operation and administration of the law creating the board of transportation fell below public expectation. The inefficiency seemed to lie in its enforcement and also in the fact that the anticipations of the public were too high. In so far as the act put an end to those abusive practices which operated to the public detriment, such as the giving of special rates and rebates, the making of unjust discriminations, overcharges, and the like, no question is opened for discussion, since their prohibition was demanded on grounds of common justice, sound economics, and public morality. The law was more or less tentative and experimental. The time has not arrived in the evolution of the

[1] *Sen. Ex. Doc.*, 1887–88, I., 152.

[2] *Evidence Maximum Rate Case*, p. 854.

railroad when control by public agencies is a finality. The degree of completeness and effectiveness which the act was designed to have could be accomplished only through the slow process of time. The radicalist anticipated too much if he expected the board to reform the abuses of economic freedom in a day. A new standard of right and wrong had to be evolved. Many of the methods and practices then in general use in railway management had to be completely changed. Time had to be given for adjustment to new conditions.

The board was not invested with power to enforce its own decisions. The efficiency of execution and enforcement was dependent upon the courts.[1] The theory of the law is that, if the directions of the board were not regarded by those affected, the courts would enforce compliance, unless justifying cause for not doing so was made clearly to appear. The law provided that the facts found by the board in any investigation and the conclusions based upon those facts should be deemed *prima facie* correct. Consequently, it was expected that the courts would compel obedience to an order of the board, unless the record of the investigation which resulted in that order disclosed an error of fact or conclusion sufficient to justify the court in refusing to take such action. But this result has not been realized, nor will this feature of the law as interpreted by the courts bear such a construction.

The effect of legal interpretation, therefore, is, when the matter comes into court, to throw the burden of proof upon the disobedient party and require it to take the affirmative of the issue. This simply means, as shown in the cases of the Lincoln Board of Trade vs. Elkhorn railroad, the Elmwood elevator case, and others, that the carriers have practically a new trial of the same question in the courts.[2] Not only so, but the courts may thus be required to pass upon a very different state of facts from those presented to the board. The roads in appearing before the board may give much or little evidence, as they choose; and then, if the decision is against them, they may go to the courts with the *prima facie* case made before the board and introduce such new

[1] Rogers vs. Hotel Co., 4 Neb., 58; State vs. Stearns, 1 Neb., 107.

[2] *2d An. Rep. Board of Trans.*, 1888, pp. 9–60; also *10th An. Rep. Board of Trans.*, 1896, pp. 73–86.

evidence as is desirable. So the whole work of the board in a given case and its decisions, however just and salutary in the public interest, may have only an impotent conclusion. This has been the actual outcome in the several cases appealed from the decision of the board. From this point of view, what the people considered the most valuable aspect of the execution of the law has resulted in more or less of a disappointment. The anti-railroad men now look to the legislature as having ultimate control and able to afford the desired relief.

The deep-seated prejudice in the public consciousness against trusts in all their forms makes it possible to fail to recognize judicious and honorable corporate management. While cognizant of the unscrupulous acts of corporate and irresponsible power, it may still be claimed economically that benefits arise from the economy of wise trust management. A disregard of this discrimination explains why many attempts at legislation have proved abortive and why a want of far-sightedness prevails, not only among corporate managers but also among legislators. This deduction only shows that public policy is variable—the very reverse of that which is the policy of the public at one time may become public policy at another. From the framing of the first organic law in 1866 to the enactment of the maximum rate law in 1893, we see in clearest perspective the change undergone in public consciousness.

Unless anti-corporation legislation is judiciously framed, it can have but a transient effect. There must be kept in mind two constant laws which govern the business of a country: first, the diminution of the margin of profit as time elapses; second, business methods must conform themselves to this diminution. These laws of trade act irresistibly, and legislation which conflicts with them is not adapted to the ever-varying conditions which are essential to the state's development. Legislation to be organic must be the result of a full and complete knowledge of the facts entering into a proposed measure. Without this, much needed legislation will defeat its own end. The futility of much of the legislation in Nebraska upon economic questions is found in its inorganic character. Moreover, the courts have adjudicated the various acts limiting the exercise of police power, and thus have made an organic conception of economic conditions a prerequisite in moulding salutary legislation.

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